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AMERICA'S RACE FOR THE MOON

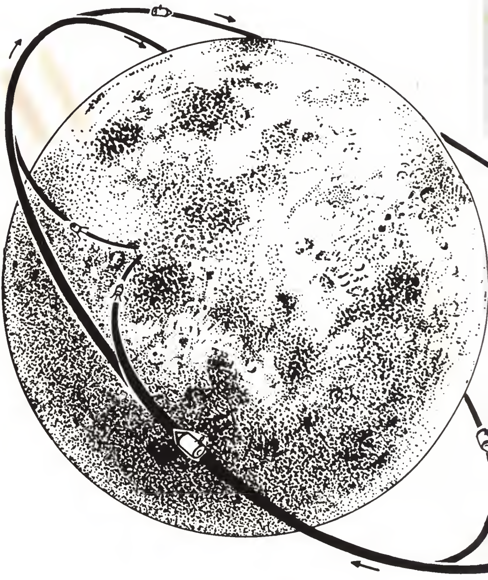
The New York Times Story of PROJECT APOLLO

Foreword by D. BRAINERD HOLMES, DIRECTOR OF MANNED SPACE FLIGHT

A RANDOM HOUSE BOOK

AMERICA'S RACE FOR THE MOON

AMERICA'S RACE

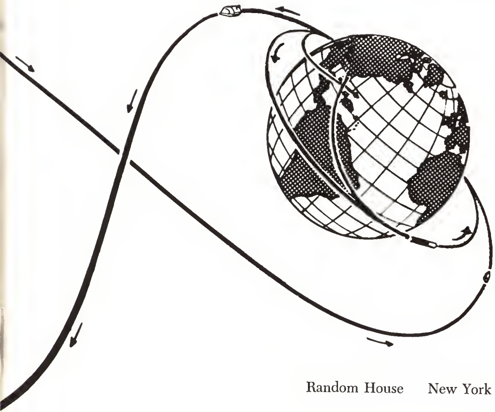


FOR THE MOON

The New York Times Story of Project Apollo

EDITED BY WALTER SULLIVAN, *Science News Editor*

Foreword by D. Brainerd Holmes,
Director of Manned Space Flight



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D. BRAINERD HOLMES

Foreword

The moon holds a strange fascination for man. Down through the ages he has named gods for it, worshipped it, and written songs, books, and stories about it. Today, he can hardly wait to put himself on it, but his interest is not just based upon mysticism, romanticism, or curiosity.

To be sure, these elements still constitute part of the moon's appeal. But reaching the moon has also become a matter of America's pride; of her desire to explore the universe; of her ability to deal better with the problems of communication, weather, and navigation; of her effort to win the world's battle between freedom and tyranny and, hence, her stake in world leadership.

President Kennedy has called the United States to the task of a manned exploration of the moon within this decade. But the President, even with the unanimous support of Congress, cannot make a manned lunar program a success. He must have the co-operation and understanding of the whole nation. He recognized this need when he said: "Let it be clear . . . that I am asking Congress and the country to accept a firm commitment to a new course of action—a course which

will last for many years and carry very heavy costs. . . . If we are to go only halfway, or reduce our sights in the face of difficulty, in my judgment, it would be better not to go at all."

We must recognize that space flight adds a new dimension to scientific study of the earth, the moon, our solar system, and the stars beyond. Each improvement in our ability to fly unmanned and manned spacecraft results in a corresponding improvement in our ability to solve nature's mysteries. What were the origins of the earth? The moon may supply the answer. Is there life similar to life on earth elsewhere in the solar system or beyond? Space exploration will help us find out.

We can also look forward to some very practical and immediate benefits from our space programs. We can improve meteorological observation and prediction with satellites that scan weather patterns and transmit signals to earth by radio. We can vastly expand the channels available for radio, telephone, electronic data, and television transmissions over great continental masses and ocean-spanning distances by using satellites as relay stations in space. We can substantially enhance the precision and safety of navigation on the sea and in the air.

It seems evident that we should go to the moon for many reasons, but for whatever reason one selects, let there be no misconception—great nations cannot mark time. This is our challenge—one of the greatest ever to face man. If we fail to undertake this challenge and let another people seize the opportunity, we may very well, in a little more than a generation, become a power secondary to the nation that accepts the challenge and grows as it conquers space.

It is a privilege to write these remarks as a foreword to a book based on an excellent series of articles on the Apollo program which recently appeared in *The New York Times*. These articles were accurate and well done, and should be most helpful in explaining this vital program to the country.

Contents

Foreword D. BRAINERD HOLMES v
Prologue: To the Moon—A Century Ago WALTER SULLIVAN 3
We Are Going RICHARD WITKIN 7
Who Is Doing the Job? RICHARD WITKIN 15
How to Get There HAROLD M. SCHMECK, JR. 22
Project Gemini—
Learning to Live in Space HAROLD M. SCHMECK, JR. 33
Spaceport U.S.A. WALTER SULLIVAN 45
Journey by Phonebooth GLADWIN HILL 54
Tracking and Communications WALTER SULLIVAN 62
Perils of the Abyss ROBERT K. PLUMB 67
Moon Pioneers—Selection and Training RICHARD WITKIN 77
What Will the Moon Be Like? WALTER SULLIVAN 87
Earth's Daughter, Sister or Uncle? DR. HAROLD C. UREY 97
Exploration by Automaton WALTER SULLIVAN 102
Tasks for the First Explorers WALTER SULLIVAN 112
Space Infection HAROLD M. SCHMECK, JR. 117
Social Impact DAVID BINDER 121
Soviet Enigma DAVID BINDER 134
Pros and Cons RICHARD WITKIN 146
Appendix
Space Glossary
Moon Facts

AMERICA'S RACE FOR THE MOON

WALTER SULLIVAN

Prologue: To the Moon—A Century Ago

Immediately after the Civil War, according to the prophetic account written in 1865 by Jules Verne, an artificial satellite was fired from Florida into an orbit about the moon. Inside were three men and two dogs.

Ironically, in this precursor of modern science fiction, the feat was the fruit of American inventive genius heavily subsidized by Moscow. The book appeared in two volumes, entitled *From the Earth to the Moon* and *Round the Moon.*

Verne, though a Frenchman, showed great admiration for American inventiveness. He said the United States had emerged from the Civil War as the leading nation in the science of gunnery. "This fact need surprise no one," he wrote. "The Yankees, the first mechanicians in the world, are engineers—just as the Italians are musicians and the Germans metaphysicians—by right of birth."

The proposal to fire a projectile to the moon was backed by the United States with contributions totaling $4,000,000, but additional funds had to be raised abroad.

"Russia paid in as her contingent the enormous sum of 368,733 rubles," Verne wrote. He said that this was not re-

markable, considering "the scientific taste of the Russians, and the impetus which they have given to astronomical studies—thanks to their numerous observatories."

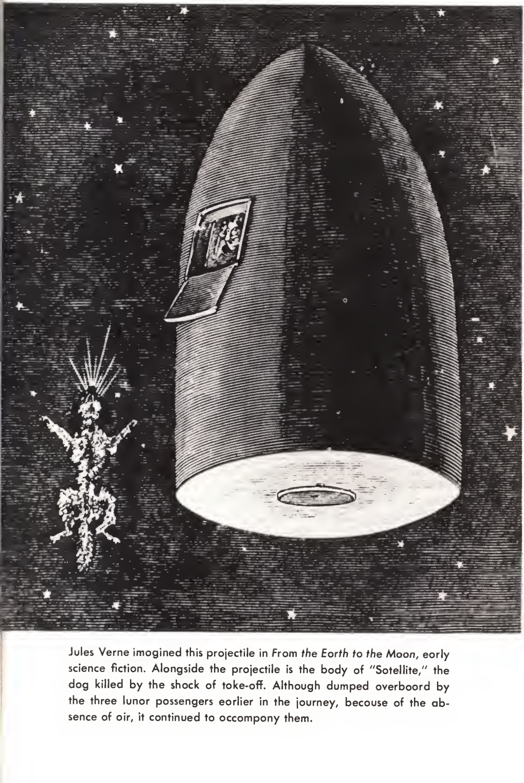
"Tampa Town" was chosen by Verne as the launching site because southern Florida "reckons no cities of importance; it is simply studded with forts raised against the roving Indians." Tampa is on the opposite side of the Florida peninsula from Cape Canaveral.

The computations of the flight trajectory and proper time and angle of fire were made by the Cambridge Observatory in the Jules Verne account. It is at the Smithsonian Astrophysical Observatory in Cambridge that Soviet and American satellite orbits are being studied on the basis of visual sightings and photographs.

The mid-nineteenth-century American venture almost collapsed because of what, in effect, was a form of interservice rivalry. Impey Barbicane, master designer of guns, thought he could pierce any armor. Captain Nicholl believed his armor was impenetrable. When their dispute threatened the moon journey, both men agreed to make the trip inside the projectile, along with a Frenchman named Michel Ardan and two dogs, Diana and Satellite.

One of the chief problems was to cushion the men and dogs against the jolt of firing. This was done with a series of water chambers, divided by diaphragms that broke in succession, forcing the water through small tubes. The system is reminiscent of one being considered for the Apollo astronauts. In Verne's account it was first tested by firing a cat and squirrel into the sky. When the missile was recovered the squirrel had vanished and the cat was happy, and fatter by the amount of one squirrel.

The moon missile was fired from a tube carved 900 feet deep into Florida rock, the charge being compressed fulminating cotton. The muzzle velocity was 25,000 miles an hour, which conforms to present-day calculations of the speed nec-



Jules Verne imagined this projectile in *From the Earth to the Moon*, early science fiction. Alongside the projectile is the body of "Satellite," the dog killed by the shock of take-off. Although dumped overboard by the three lunar passengers earlier in the journey, because of the absence of air, it continued to accompany them.

essary to escape from the earth's gravity (assuming no air drag).

America went "moon-mad," Verne said, and hoped to claim all territory on "The Queen of the Night." The vehicle was 108 inches in diameter, with a 12-inch aluminum shell, and weighed ten tons.

On the way the Frenchman offered his American companions Chambertin wine, vintage 1853. They missed the moon and hence went into an elliptical orbit around it. The vehicle had been equipped with retro rockets to slow its fall as it neared the moon's surface and these were used to jolt the satellite out of its orbit. It thereupon fell back to earth, flaming like a meteor, and plunged into the Pacific, from whose depths it bobbed to the surface. Its passengers, protected by the heavy shell, were unhurt.

At the end of his account of a trip to the moon, Verne speculated on the inevitability of interplanetary travel. "Knowing the bold ingenuity of the Anglo-Saxon race," he said, it was likely that the first such travelers would be Americans.

RICHARD WITKIN

We Are Going

By 1970, perhaps as early as 1967, three Americans will be rocketed on a journey that, until Sputnik I, only a few visionaries believed would ever take place.

Today, at a hundred hushed laboratories, at a hundred clattering factories and on a thousand cluttered drafting boards, the blueprints, the maps, the machines, the methods for that epochal journey are already taking shape.

The American astronauts will be journeying to the moon. It is the nation's hope that Russians will not have reached there first.

For the public at large, jolted by a succession of Soviet space spectaculars, the chances of actually beating the Russians to the moon have never seemed bright. They seemed dimmer than ever when, on August 11 and 12, 1962, two manned Soviet Vostoks were rocketed into orbits so amazingly precise that, Russia claims, the craft came within three miles of one another. Joining two craft in orbit is a key to the United States lunar plan, and probably to Russia's too. This country does not plan its first attempt to rendezvous two craft in orbit until 1964, so the flights of the twin Vostoks

Returning fram the Maan: Drawing shows three astranauts in an Apalla cammand capsule prapelled by a cylindrical service madule that will be jettisoned upon re-entry inta the earth's atmasphere. The vehicle is based an a drawing by the Marquardt Carp., develaper af the attitude-control system. Phatagroph af maon by the Mount Wilsan and Palomar Observataries.

have given the Russians a large head start in a vital phase of the lunar contest.

Despite this, the men running the United States program were still confident this country could be first to the moon because the "pacing item" in the race was not rendezvous in orbit but development of the outsized new rockets needed for lunar journeys. Initial evidence was that the Russians had made no leap forward in rocket size—they themselves said the twin Vostoks were about the same size as those orbited previously.

Whoever wins the race to the moon, it will be an event with no parallel in history. Not even Columbus' opening of the New World or the Wright brothers' first flight had consequences as profound as may emerge from the first lunar voyage.

Throughout his existence, man has been confined to his little planet by massive restraints of gravity and a space environment ruthlessly hostile to life. He was, that is, until April 12, 1961, when Major Yuri Gagarin of the Soviet Union became the first man to orbit the earth in a space ship.

In overcoming these restraints and reaching the moon, man will have set foot for the first time on a celestial body other than the one on which he was born. He will have come into possession of a Rosetta stone whose deciphering could tell the story of the origin of the solar system. He will have made the first in a succession of leaps that will end no one knows where.

The first landing will be hardly less significant if disaster should overtake the expedition and prevent the safe return of any or all the crewmen. Others will follow and return alive.

Lunar landings are expected to lead to the establishment of more or less permanent lunar bases, scientific and perhaps military. There will be later flights in which man may land on other planets and even—so some predict—reach other solar systems.

The United States' manned lunar program was initiated in 1961 in a speech to Congress by President Kennedy delivered a month after Major Gagarin's flight. The program was given the name Project Apollo. It will cost about $20,000,000,000—ten times the cost of the Manhattan District atom-bomb project in World War II.

Project Apollo will enlist the talents of 100,000 persons and strain the technological ingenuity of many industries. Electronic devices will have to withstand the rigors of space flight with the same degree of reliability that the finest on-the-ground equipment affords without such punishment. Astronauts will need space suits with perfectly sealed, bellows-like joints, to allow them to walk the lunar surface. And they will carry miniature utilities plants on their backs to provide oxygen, a means of cooling and other life support.

Rockets half the height of the Washington Monument must be perfected. Giant caterpillar-tread earth-crawlers must be built to transport the rockets from forty-five-story assembly buildings across Cape Canaveral to their launching pads.

Without doubt, Project Apollo represents the most challenging task the nation has ever undertaken except in war. The Russians may be pursuing a comparable program with equal urgency. However, informants with access to intelligence information profess ignorance of the Soviet timetable for the moon.

In any event, the first American expedition will have an impact peculiarly its own. The take-off will be witnessed, as was that of Lieutenant Colonel John H. Glenn, Jr., this country's first astronaut to orbit the earth, by millions at their television sets. Major Gagarin's flight had no such audience. With communications satellites like Telstar in regular operation, anyone, anywhere on the globe, will be able to participate vicariously in the start of the lunar adventure.

This is the flight plan as now drawn up: For three days the explorers will soar, weightless, on an elliptical path aimed,

Wide World

Lunar Ferry: This is how a vehicle for travel between the moon and main space ship might look. Model is displayed at the NASA center in Houston during speech by President Kennedy. Two of three men on the main ship would fly to the moon and back in a glass cockpit near the top. Outer globes hold pressurized supplies such as oxygen.

like a duck hunter's shot, in front of the moon's line of travel. As lunar gravity eventually pulls their spacecraft toward the cratered lunar surface, they will fire a rocket to swerve themselves into a circular orbit around the moon. Then two of the crewmen will make their way, with handrails or mesh grips, into a space ferry joined nose-to-nose to their main "command" capsule.

They will give the ferry, or "bug" (so called because of its long spindly legs used in the lunar landing), a final check and cast off. Rockets will ease them down to an area on the leading, sunlit side of the moon (to the left as viewed from earth) within ten degrees north or south of the lunar equator. After an exploration that may last a few hours or as much as two days, the astronauts will board their ferry and begin their countdown check, a task that requires scores of technicians before a Cape Canaveral blast-off.

Finally, the lunar explorers will take off, soar back to lunar orbit, and make fast to the "mother" craft. They will crawl back into the command unit, rejoining the astronaut left behind to man it. They will cut loose the ferry, then rocket back to earth.

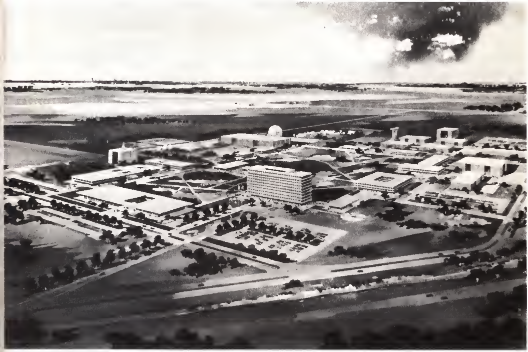
When President Kennedy proposed Project Apollo, he urged that the nation try to accomplish it "before this decade is out." By using the lunar-bug technique, it may be done as early as 1967. The decision to save time and money by concentrating on this approach was announced in July 1962 following a six-month study.

Previously, priority had been assigned to a technique requiring a rendezvous of space vehicles on the outbound trip, during earth orbit, rather than on the return trip, during lunar orbit. An entire three-unit spacecraft would have landed on the moon. Two boosters would have had to be launched from the earth, in precisely timed sequence, instead of the single one needed in the lunar-bug approach.

In deciding on the lunar ferry, officials left themselves sev-

eral outs. They said they would continue studies of various alternatives. They cautioned that any of several assumptions they were proceeding on might be exploded as work progressed. They said it was important to retain flexibility, so that, if unexpected hurdles arose, the program could be reoriented with minimum delay.

Today anyone looking in on locations where Apollo work is under way gets the impression that the project is already in full swing. At North American Aviation's Downey, California, plant, full-scale wooden mock-ups of Apollo capsules have been put together, complete with dashboards worked out to the last toggle switch. There are drawers along the



Space Flight Headquarters: Adjacent to Clear Lake, near Houston, Texas, NASA is building its multimillion-dollar Manned Spacecraft Center. When finished in 1964, it will be headquarters for our journeys to the moon.

sides of the capsule, like compartments in an antique apothecary chest, labeled Food Storage; Tools; Splints; Oral Drugs; Injection Drugs; Scientific Equipment; Waste Storage.

At the AiResearch plant just off Los Angeles International Airport, a vacuum chamber was kept going eighteen hours a day recently while volunteer physical-education students tried out an initial design for a space suit.

In a cramped, one-story Houston, Texas, laboratory, a recent visitor looked in on a six-ring circus. In one room, a technician in a space suit was walking furiously in place while a supervisor issued instructions over an intercom. Next door, engineers were testing materials to serve as shock-damping back supports for astronauts under deceleration forces. One support was a hammock-like net made of synthetic fibers that would stretch without losing strength, and would not bounce back and snap an astronaut's neck. A second scheme was to make a couch of "silly putty." The third was to use a mattress filled with thousands of tiny "micro balloons" that would assume the exact shape of an astronaut's back when air was pumped from the mattress.

"If I'm ever fired," said the engineer in charge of the fibers, the putty and the micro balloons, "I'll take this stuff to Atlantic City and open up on the boardwalk."

Apollo engineers will be experimenting with a good many other new rigs and devices before they finally have their lunar vehicle ready for its ultimate journey.

Apollo is in its early laboratory stages. But so swift is the pace of events as man reaches beyond his earth that it will be no time—as time has been reckoned till now—before he has stepped out on the moon and started peering restlessly toward Venus and Mars.

RICHARD WITKIN

Who Is Doing the Job?

If there had been one, the "help wanted" advertisement might have gone like this: "Wanted—a strong man to do a \$20,000,000,000 job that may take till 1970. Must have impeccable references, dogged devotion to duty, sharp eye for detail and intolerance for anything less than perfection."

Objective evidence and the testimony of family, friends, and associates indicate that the Government has found such a man in Dyer Brainerd Holmes, a forty-one-year-old engineer who reported to work in November 1961 to direct the American program for putting a team of astronauts on the moon. He has an expressive face dominated by large, inquiring eyes; a refreshingly unpretentious manner, and an impressive record as manager of outsize projects. Former associates at the Radio Corporation of America praise his warm and friendly personality. They report that he has a cool, no-nonsense approach to any job he tackles.

One engineer who has had intimate dealings with Holmes says: "He forms an opinion fast and blurts it right out. It takes people a little while to get used to. But he is good at mending fences after feelings have been rumpled."

Brainerd Holmes was born in Brooklyn on May 24, 1921, and grew up in East Orange, New Jersey. He was graduated as an electrical engineer from Cornell University in 1943 in absentia, while he was in the Navy. But the Apollo director has not specialized in a particular engineering discipline. He has made a success of managing broad-gauge projects in which he has had to organize teams of other engineers.

Starting with R.C.A. in 1953, Holmes was given more and more responsibility until, on June 1, 1961, he became general manager of the company's major defense systems division in Moorestown, New Jersey. But he was not to hold down his new post long. Just a week before he took it on, President Kennedy proposed the Apollo project. And the search for a man to manage it soon reached Holmes and brought a bid for him to join the New Frontier.

He had built his reputation on three military projects: the Talos, a Navy ground-to-air missile; the electronic system that reduced the countdown for the Atlas intercontinental ballistic missile from hours to minutes; and, biggest of all, the Ballistic Missile Early Warning System (BMEWS) installations in Greenland, Alaska, and England. He was the first operations manager of BMEWS, and then manager.

While he was with BMEWS, he managed an operation that involved at least four major subcontractors, some 2,900 supply and servicing companies, a total of about 10,000 people, and a cost of about $1,000,000,000.

Four days after the first site at Thule, Greenland, came into operation, Holmes found in a dramatic way that the radar was working better than expected. There was an emergency, middle-of-the-night call from the Colorado headquarters of the Air Defense Command. The lower of the two Thule radar fans had turned up all sorts of "targets," and the alarm had been instantly flashed to Colorado. Holmes, asleep in Moorestown, was awakened by an aide assigned to the Defense Command. The aide hinted—because the matter

was highly secret—at what had happened and suggested that he thought the "targets" were just reflections from the rising moon. Holmes was cool, as he usually is under pressure. He pondered and quickly agreed that it was the moon.

And so it was. But the phone calls continued for two hours more.

Holmes's title is director of the space agency's Office of Manned Space Flight, which has temporary headquarters in a Washington office building. He has responsibility not only for Apollo but for the current Project Mercury program of one-man earth-orbit flights and an important intermediate program known as Project Gemini.

Gemini spacecraft will be two-man vehicles. They will be used for earth-orbit flights lasting up to two weeks. In addition, they will be used, in conjunction with unmanned Agena craft, to develop techniques for rendezvous and joining of two spacecraft in orbit.

The Apollo director also has an intimate interest in the progress of other unmanned space flights outside his direct authority. He is looking to many of these experiments to provide data needed for his own manned space-flight program. Flights of Atlas-Centaur vehicles, for instance, should provide the first data on the workability of high-energy liquid-hydrogen upper stages. Much larger liquid-hydrogen rockets will serve as the upper stages of the three-stage boosters that will send Apollo expeditions to the moon.

Broad-gauge policy decisions in the program are taken by a "general partnership" of the three top officials of NASA. They are James E. Webb, administrator of the agency and originator of the partnership concept; Dr. Hugh L. Dryden, deputy administrator, and Robert C. Seamans, Jr., associate administrator. Until now, there have been no dissents. The systems engineering team whose task is to analyze missions, systems and equipment considered for use in the Apollo program is headed by Dr. Joseph F. Shea, who helped to develop

the Titan missile guidance system. The Shea team is assisted in gathering the facts needed to make its recommendations (such as the lunar-ferry recommendation) by Bellcomm, a private contractor jointly owned by the American Telephone and Telegraph Company and the Western Electric Corporation. Another team is responsible for integration and checkout of the entire spacecraft-booster combination. It is headed by James E. Sloan, a former assistant of Holmes, at R.C.A. The General Electric Company will assist in this work.

A 1,600-acre site has been acquired in Houston, to accommodate a new headquarters for NASA's Manned Spacecraft Center. Its director is Dr. Robert R. Gilruth, Project Mercury field director from the start. The Center is responsible for overseeing production of Apollo spacecraft units, as opposed to rocket boosters, and for selection and training of astronauts. The Houston operation currently is scattered over a dozen leased factories, architects' offices, garages and other facilities.

Cylindrical prototypes of Apollo's 7,500,000-pound-thrust first-stage boosters are being developed at NASA's George C. Marshall Space Flight Center in Huntsville, Alabama, under the direction of Dr. Wernher von Braun, whose Huntsville team, still largely intact, put the nation's first satellite, Explorer I, into orbit on January 31, 1958. These boosters will ultimately be built by the Boeing Company.

In charge of NASA's facilities at Cape Canaveral is Dr. Kurt Debus of the original von Braun team. The acquisition of 88,000 acres for these facilities will increase the size of the Cape launching center more than five times.

The program is rapidly gaining momentum. Many key contracts have already been announced, including one of $400,000,000 to North American Aviation for production of two of the three Apollo spacecraft units.

One is the cone-shaped three-man command capsule in which the lunar explorers will ride to lunar orbit and later

D. Brainerd Holmes.

make their fiery return through the atmosphere to a landing on earth. The other is the cylindrical service module attached immediately below the command unit. It will contain propulsion rockets for braking into a lunar orbit and the return to earth, electrical power and other equipment.

Proposals for the third unit, the two-man ferry the nation hopes will be the Santa Maria of lunar exploration, were submitted at NASA's request, by nine aerospace companies. Spacecraft subcontracts have been awarded to the Massachusetts Institute of Technology, for development of the guidance system; the Minneapolis-Honeywell Regulator Company, for the stability and control system; the Collins Radio Company, for the telecommunication system; the AiResearch Manufacturing Company, for the environmental control system; the Marquardt Corporation, for the reaction control system; the Avco Corporation, for the heat shielding, and Pratt and Whitney Aircraft, for the fuel-cell power source.

Holmes and others in the Apollo high command display the energy and confidence that might be expected of men who have erected radars each larger than a football field and successfully carried out critical assignments in various missile programs. But they are intensely aware that Apollo is a project so bold in concept, and so vital to the nation's future, that nothing—not even a spare transistor for a minor circuit—can be taken for granted.

When the engineers finish reeling off particular problems, they usually return to two across-the-board concerns. One is reliability—the need to build into every component a degree of reliability beyond anything demanded in the space program up to now.

The other is organization.

Holmes must make sure—week by week, month by month—that thousands of tasks going on across the country, indeed, around the world, are accomplished within tightly meshed

time schedules. He must make sure that, when the pieces are brought together, they will fit.

In the end, he must rely on people. He has had to recruit a lot of people for great responsibilities at limited government salaries, in a time period ordinarily deemed too short for getting the best results. He has had to promote a co-operative spirit between organizations accustomed to running development efforts more independently—organizations with spirited directors who could be expected to resent any reining in. He has seen encouraging signs that his sprawling organization can be made to pull smoothly toward the single objective. What may enable talented but fallible men to meet the staggering demands placed upon them is the knowledge of each that he is contributing to history's greatest venture.

Before the decade is out, human beings will walk on the moon and beckon their fellows to follow.

HAROLD M. SCHMECK, JR.

How to Get There

The National Aeronautics and Space Administration has transferred the nation's most dramatic parking problem to the vicinity of the moon.

The idea of lunar-orbit rendezvous was pioneered by Dr. John C. Houbolt, of the space agency's Langley Research Center, in Virginia. It is one of four basic strategies that have been considered for the initial moon mission. A fifth is also being studied, but only as a back-up in case unforeseen difficulties appear.

To some degree lunar exploration is a numbers game in which the lifting capacity of rockets is juggled against the payload weight that must be sent to the moon. The launching vehicle being developed is the advanced Saturn C-5. It is capable of putting about 90,000 pounds in a trajectory to the moon. This is the largest launching rocket now being developed by the United States. Prime advantage of the moon rendezvous is that it makes possible a manned lunar mission by sending an 85,000-pound packet to the vicinity of the moon. A single C-5 launching rocket should accomplish this.

The two other flight plans considered most seriously—earth-orbit rendezvous and a direct-flight three-man landing—each would require 150,000 pounds.

In the earth-orbit-rendezvous method two C-5s would be launched. They would rendezvous in a parking orbit above earth. One would carry the spacecraft and the propulsion rocket to send this to the moon. The other would be a tanker to complete fueling of the moon rocket. The direct-flight plan would have used a Nova vehicle, substantially more powerful than the Saturn, to send 150,000 pounds directly to the moon. This would have required a 12,000,000-pound-thrust, first-stage booster—almost twice the size of those needed in the alternative methods. The fourth possibility has been called moon-surface rendezvous—a mission in which some fueling and preparations for the return journey would be carried out on the moon with supplies sent previously. The fifth scheme—the one being studied as a possible back-up—is a two-man direct flight that could be accomplished with one C-5 launching vehicle.

The C-5 for moon exploration is to be a huge three-stage vehicle. Its advanced development has been under way only since January 1962 and will require the design and building of two new rocket engines. The largest of these engines is the F-1, standing 20 feet tall and capable of generating 1,500,000 pounds of thrust. The other is the J-2, designed to burn liquid hydrogen with liquid oxygen and develop 200,000 pounds of thrust.

The first stage of the C-5 will cluster five F-1 engines burning kerosene and liquid oxygen and developing a total thrust of 7,500,000 pounds. The second stage clusters five of the J-2s, and the third stage will be powered by a single J-2.

The C-5 rocket, with its Apollo spacecraft, will weigh 6,000,000 pounds as it poises fully fueled on the launching pad at Cape Canaveral. It will have a base diameter of 33 feet and will stand about 360 feet high with the spacecraft.

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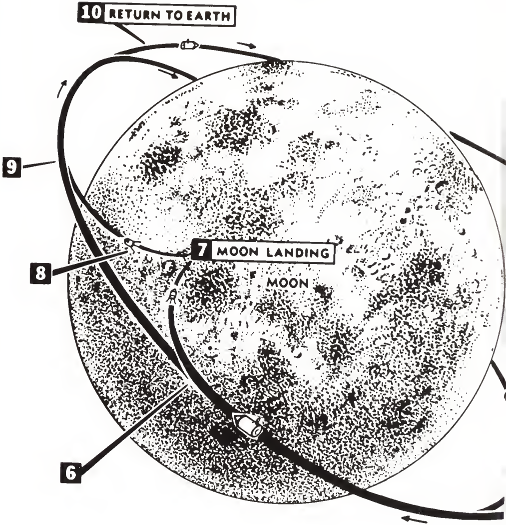
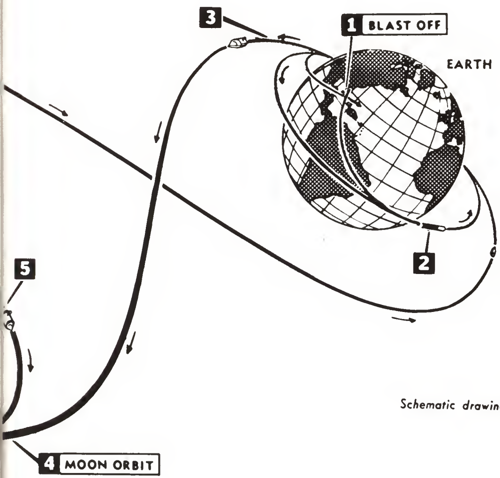


The following is the sequence of events projected for the first londing of Americans on the moon: 1. Blost-off from Cape Conoveral of three-stoge Advonced Saturn racket. 2. Cut-off of third stoge after portial burn-out. Vehicle orbits earth. 3. Re-ignition of third stage ta inject vehicle into trojectory toword moon. 4. Ignition of retra rockets ta ochieve orbit oround maon. 5. While orbiting, two men climb into "bug,"

U. S. PROGRAM FOR A MANNED LUNAR LANDING



Schematic drawing

or lunor excursion vehicle. 6. Detochment of bug for descent to lunar surfoce. 7. Lunor landing. 8. Toke-off from moon timed to rendezvous with moin vehicle, which meonwhile hos orbited moon with one mon oboord. 9. After return of two ostronouts to main vehicle, bug is jettisoned. 10. At proper point in orbit, rocket is fired to drive moin vehicle bock to earth.

This vehicle so far has the best chance of being the first to carry an American to the moon. The sequence of events for the historic mission as it is now conceived is as follows: The whole complex lifts off the launching pad with the burning of the first stage. Next, the second stage burns to give added velocity. Then the third stage burns briefly and is shut down. This puts the third stage and the spacecraft in orbit around the earth. These complete at least one half an orbit while the systems are checked out and the vehicle approaches the proper point for firing to the moon.

Calculating where the moon will be when our men get there will not be easy. The moon's orbital movement is simple in gross terms, but extremely complicated in precise terms. It is affected by such factors as the lopsided shape of both the earth and moon, as well as the constantly changing relative positions of earth, sun, moon and planets.

Another difficulty, in long-term prediction, is that the moon itself causes time on earth, as we usually define it, to slow down. This is because the tides generated on earth by the moon cause friction, slowing down both the earth's speed of rotation (our "day") and the moon's orbital speed (the traditional "month").

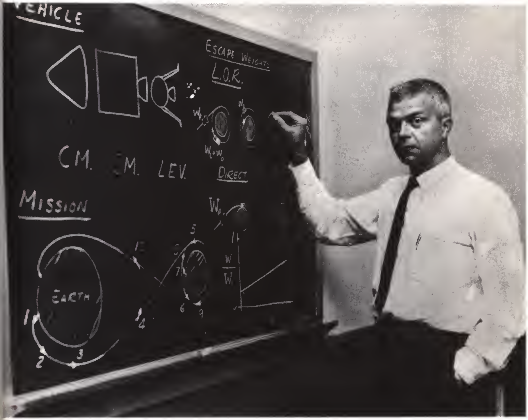
If all is well when the favorable launching point is reached, the third stage fires again to put the craft on an escape trajectory to the moon. Now the lunar mission begins.

After this comes the first sophisticated maneuver in space that the astronauts must make with their craft. When the C-5 lifts off the pad at Cape Canaveral the bug, which will be used for the lunar landing, is the rear-most component of the spacecraft, riding just ahead of the launching rocket's third stage. For its ultimate mission, however, it must be linked nose-to-nose with the command module at the "front" end of the train. Furthermore, the service module's rocket propulsion must be freed for possible emergency use.

To achieve these ends, the service module and command

module separate from the rest of the vehicle, move off a little and then come back so that the nose of the command module can link with the nose of the bug. Then the launching vehicle's third stage is pushed away.

About sixty-five hours later, the spacecraft reaches the vicinity of the moon and is put into orbit at an altitude of about 100 miles over the lunar equator. Now the three-man



Dr. John C. Houbolt, who worked out the lunor-orbit rendezvous scheme, explains details of the flight on a blackboard. He is on the stoff of the Langley Reseorch Center in Hampton, Virginio. The components of the moon vehicle identified by initials (upper left) ore: command module, service module ond lunar excursion vehicle.

crew checks again the "health" of their craft and prepares for the step to which the twenty-billion-dollar project is dedicated—the landing on the moon.

Two men transfer to the bug, separate it from the mother craft and put themselves into an orbit with the same period as that of the mother craft, but having a low point only about ten miles above the surface. This will allow the astronauts to take a fairly close look at the pre-selected landing site.

When they decide to go down the rest of the way, the landing vehicle's engine burns again and brings the bug down close to the surface where it can hover for a minute or move across the lunar terrain, just above the surface, before deciding to land. During the hovering phase it is still possible to abandon the landing and return to the mother ship.

After the two-man vehicle lands, the astronauts should be able to stay on the surface as long as four days. But probably, in the first moon landing, they will actually remain a much shorter time. After exploring, the two astronauts will recheck their vehicle, wait for a proper launching period (this will have to be timed to within a few minutes), and take off to rendezvous with the mother craft. If their bug fails to rendezvous, the mother craft will be equipped to go after it for a second attempt. Once they have rejoined the main Apollo spacecraft in orbit 100 miles above the moon, the bug will be cast loose and the three men will start their main propulsion engine for the sixty-hour-plus return to earth.

While the bug is on the lunar surface, the orbiting mother craft will be beyond the horizon much of the time. During these periods the men on the surface will not be able to talk directly to their colleague in orbit. All their messages will have to be relayed 500,000 miles to earth and back.

The two most crucial problems are the lunar landing and the final rendezvous in lunar orbit for the return to earth. The former is much simplified by landing the bug, a relatively small vehicle designed for that specific purpose. Bringing it

down safely should be less difficult than landing the entire three-man Apollo spacecraft.

The bug is expected to stand about 20 feet tall and weigh 15 tons. The combination of command and service modules would stand 25 feet tall and weigh a total of 28 tons. For a lunar braking and touch-down they would also have to be equipped with two additional rocket units totaling 50 tons.

The countdown for the take-off of the lunar ferry from the moon to rejoin its mother craft in lunar orbit will be much briefer and simpler than one at Cape Canaveral. Much of the

D. Brainerd Holmes and Dr. Joseph H. Shea of Project Apollo demonstrate with models how the lunar excursion vehicle (left) will dock, nose-to-nose, with the main moon vehicle (right).

routine customary before an earth take-off will have been adequately taken care of before the Cape Canaveral launching.

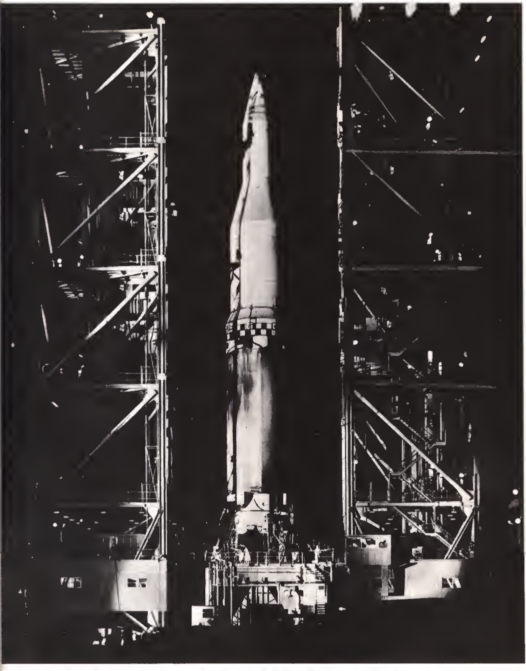
Automatic check-out devices and displays will indicate to the two astronauts in the bug whether everything is ready for the lunar take-off. As one engineer has commented: "You can't call Canaveral from the moon to ask for spares." The ferry, however, may have a limited number of spare parts. Or spares could be available aboard an unmanned logistics vehicle that may be sent to the moon ahead of the manned expedition.

The abbreviated countdown will have to be timed so that the take-off can be made within a six- or seven-minute launch "window." The close timing is mandatory if the ferry is to be able to intercept the mother craft orbiting 100 miles overhead at 3,400 miles an hour. If the time window is missed, the astronauts will ordinarily have to wait about two hours until the mother craft comes around again.

There will be an emergency take-off plan in case of some catastrophic event on the moon, such as a volcanic eruption. One procedure calls for the astronauts to launch themselves into a low orbit below the mother craft's and then transfer to the higher orbit when the two craft whirl into the proper relative positions. Limited errors in the accuracy of the ferry's guidance system will not be fatal, since the mother craft will be able to alter its trajectory to a limited extent to maneuver toward the ferry. If the ferry's guidance should go far astray, the two astronauts on board would be doomed.

Take-off propulsion will probably be provided by a single rocket using a liquid, hypergolic propellant, and an engine simplified by the absence of pumps and throttle. A hypergolic propellant ignites spontaneously upon contact with an oxidizer, and a rocket of this type is considered virtually as reliable as a solid-propellant rocket.

A premature shutdown of the rocket after take-off, how-



First of the "big" rockets, this Saturn C-1 was successfully test-fired from Cape Canaveral in October 1961. It, in turn, will be dwarfed by the Advanced Saturn vehicles that carry men to the moon.

ever, would be as fatal as a gross guidance error. To reduce this possibility to the barest minimum, the rocket not only will be designed with great precision but will also have redundant valves and other key parts that could take over if some mechanism failed in flight.

When the first men land on the moon, they may find a cache of supplies awaiting them. Plans are being drawn for a Lunar Logistic Auxilliary, or "vehicle," that would carry a load on the shoulders of an Advanced Saturn and soft-land it at the proposed site for manned landing.

HAROLD M. SCHMECK, JR.

Project Gemini—Learning to Live in Space

The United States will spend more than $200,000,000 in the fiscal year 1962-63 for something that will go up like a rocket, come down like a meteor and land like an ordinary light plane.

This is the Gemini, the two-man spacecraft with which the nation will take its first giant step toward the moon. The initial flight may be made late in 1963. Others will be during 1964, according to the latest timetable of the National Aeronautics and Space Administration's Project Apollo.

In the Gemini, American astronauts will learn the basic skills of living and working in space. They will learn what it is like to stay as long as two full weeks in orbit. Probably they will try climbing out of their spacecraft and floating on nothingness more than 100 miles above the surface of the earth. They will become practiced and efficient in performing tasks that no man has ever yet accomplished. They must do all this in a dozen or so flights during little more than a year.

Foremost among the space skills they must learn are those of rendezvous and docking. In the rendezvous, a spacecraft finds and maneuvers close to another object in space. Dock-

ing is the actual coupling of one orbiting object to another.

These maneuvers are far less simple than they sound. By the fall of 1962 no space docking had ever been achieved, although the Soviet astronauts, Major Andrian G. Nikolayev and Lieutenant Colonel Pavel R. Popovich, had ridden capsules to within three miles of each other. Yet rendezvous and docking are crucial to Project Apollo. The, Gemini, though it will stay relatively close to earth, will be a vital step toward a round-trip expedition to the moon.

"It will not suffice to accomplish rendezvous once or twice as a space age marvel," says James T. Rose, Gemini's project engineer for mission planning at the Manned Spacecraft Center in Houston. The technique must become as much a matter of skilled, efficient routine as the comparable maneuver is today in the air and on the sea. An economical, dependable, fast technique must be developed that will work not only for the Gemini flight but also for future flights.

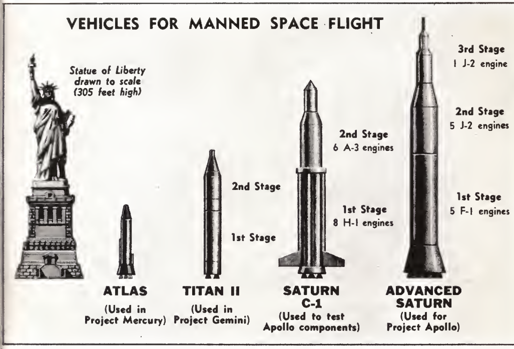
At first glance, the solution to rendezvous problems might seem simple. Why not launch one space vehicle into a circular orbit; later launch the other into virtually the same orbit and then adjust the speeds of the two vehicles until they come together, like two horses on a race track?

Unfortunately, this is no more possible than it is for one seat on a Ferris wheel to catch up with another. If the speed of an orbiting object increases, the orbit changes and the object flies farther outward. Conversely, if the speed is decreased, the object curves in closer to the earth. Thus, two objects well separated but flying the same orbital path cannot be brought together by simple adjustments of speed.

Another misleadingly "obvious" solution might be called the "wing shot" technique, in which, with one object in orbit, the other would be fired with the proper aim and at the proper time to have the two meet directly. This is possible, but exceedingly difficult. To effect such a meeting, the firing of the second vehicle would have to come at almost precisely

the right moment. If the method were used in a Gemini flight the allowable error in launching time would be only a matter of seconds.

In the projected Gemini experiments, the spacecraft, launched by a Titan II missile, will rendezvous with a 32-foot-long Agena rocket launched earlier by an Atlas. The technique being planned now is about as follows: The Atlas launches the Agena into a nearly circular orbit about 150 nautical miles above earth. Later, the Gemini craft is sent up into an elliptical orbit with its apogee, or highest point, also 150 nautical miles out and its perigee, or low point,



Space Boosters: The Advanced Saturn C-5 will stand higher than the Statue of Liberty. The rocket that is scheduled to carry United States astronauts to the moon sometime between 1967 and 1970 towers above the Atlas of Project Mercury and the Titan II, scheduled for use in Gemini.

about 85 miles out. The "launch window" or allowable time margin for achieving this launching in about the desired plane is up to a few hours, a degree of timing accuracy that is certainly attainable.

With the two vehicles placed in orbits that touch each other at apogee, one will gradually "catch up" with the other in a few orbits. As they approach within a reasonable "capture volume," a three-dimensional jockeying of speed and direction can bring them close together.

Actually, two basic problems are involved in a rendezvous. One is plane error, difference between the planes of the two orbits. The other is phase error. Phase refers to the point in its elliptical or circular orbit path that an object occupies at any given time. Special techniques can expand the launch window so that the launching can be done at any time within a period of a few hours with no great production of plane error. Without such techniques the window would be only a very few minutes. The launching teams must also pick a launching time that will produce the least error in phase.

Both the spacecraft and the Agena are capable of maneuvering to achieve a rendezvous. The Agena is capable of correcting gross errors that could not be handled by the spacecraft. It therefore could make possible rendezvous missions that might otherwise have to be halted because of the size of the initial errors. Though unmanned, the Agena will be capable of stopping and restarting its engines several times in flight. It can be controlled either from the ground or from a spacecraft.

At the range of about 250 miles, the Gemini spacecraft's radar is expected to pick up the target Agena. Then the final stage of rendezvous can begin. In this phase the two objects will be brought on an interception course and the relative velocity between them largely eliminated. The docking phase begins at perhaps a quarter of a mile when the relative difference in speed of the two objects has been cut to about two miles an hour.

Though both the Agena and the Gemini will be traveling at about 17,500 miles an hour around the earth, the relative speed with which they approach and touch each other in docking has to be kept down to less than two feet a second. This is less than one and a half miles an hour.

In the final maneuver the cone-shaped end of the Gemini will slide into a matching cone at the Agena's nose. An indexing bar rising vertically from the Gemini's nose will help the pilot judge the distance. It will fit into a groove in the Agena's nose. The two vehicles will latch together and will be able to operate as a single craft under the Agena's rocket power until they uncouple at the end of the experiment.

The space agency is concerned in developing rendezvous skills only in the interests of peaceful research and exploration. However, it is obvious that the same skills are of great potential importance to military space operations, too. Details of some of the techniques that will facilitate rendezvous in orbit, in fact, are classified.

Preparing astronauts for the feel of living and working in the harshest environment man has ever known is part of the Gemini's task. This objective is to put men in orbit for as long as two weeks, to see how this experience affects them and to train them to work under the bizarre conditions of long-term weightlessness.

Rendezvous experiments will probably be carried out on missions of a day or so. But during the long space flights, astronauts may try climbing out of their orbiting vehicle and floating free, except for a tether line, in space. Such a venture may give some astronaut the chance to look downward and see North America 100 miles beneath his unsupported feet. The experiment has a purpose beyond such bizarre experience. Possibly in Apollo, and certainly in later aspects of manned space exploration, men will need to climb out of their vehicles and work in space. The Gemini is equipped to give them primer lessons in how this is done.

In silhouette the Gemini vehicle is much like the Mercury

capsules in which American astronauts have already orbited earth. In outside dimensions, Gemini is only slightly larger. The Gemini is designed to carry two men, or one man and a modest menagerie of experimental animals. Its weight is to be nearly four tons when equipped for the rendezvous experiments—slightly less for the long duration flights. The Mercury capsule weighs only about one and a half tons in orbit.

The Gemini will also carry an on-board digital computer to help in the rendezvous and re-entry maneuvers. The device will fit in a space of about a cubic foot and will weigh about 65 pounds.

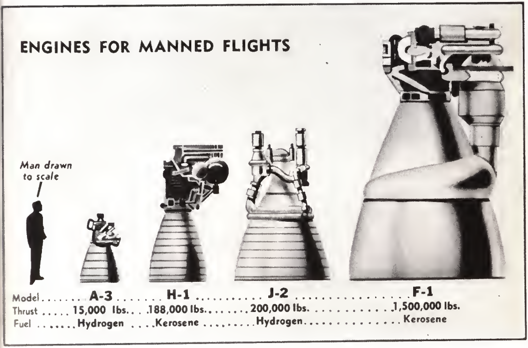
The Gemini will have motion and acceleration-sensing equipment collectively called an "inertial platform" to feed navigation data to the computer and to the pilots. To aid in the rendezvous, there will be a compact radar set weighing only about 65 pounds and designed without rotating antenna. To supply power for the spacecraft's many needs the Gemini will carry fuel cells capable of a peak load of two kilowatts. These will be backed up by batteries. Fuel cells are devices designed to convert chemical energy directly into electricity. They differ from storage batteries in having fuel components that are fed continually into the cell for use. The cell continues to generate electricity as long as the fuel is supplied. In the case of the Gemini, the fuel components will be hydrogen and oxygen.

Much of the Gemini's necessary supplies are housed in two sections, called adapters, that fit between the top of the launching rocket and the blunt end of the main spacecraft. The inner adapter holds the retro rockets; the outer one contains the control-system fuel. They are separated from the spacecraft before re-entry to bare the heat shield.

Inside the main portion of the spacecraft is the slab-shaped, pressurized compartment housing the two-man crew. The

amount of "leg room" for the two astronauts will be a little greater than in Mercury but the effects of the tight fit may be eased somewhat by another feature of the Gemini design. The spacecraft will have no rocket-launched escape tower such as the Mercury carries to pull the capsule free from the launching rocket in case the latter explodes on the launching pad or fails early in flight. Instead, the Gemini will be equipped with catapult ejection seats like those used on modern fighter aircraft.

In case of mishap on the pad, early in the flight, or even after re-entry, two hatches will fly open and both astronauts



Power for Apollo: The F-1 engine (right) to be developed and clustered for moon flight will generate alone as much thrust as the eight H-1 engines in the first stage of Saturn C-1, the largest United States rocket launched to date. Other engines ranging to left compared with size of man.

will shoot outward beyond the spacecraft and will float to the ground by parachute. The Mercury capsule needs 270 electrical relays to insure that the escape tower and parachutes can function safely at all times. By using ejection seats controlled by the astronauts, this number could be cut to eighty. To achieve this saving, it is necessary that the escape system be operated manually by the pilots rather than automatically.

Whether this arrangement works depends in part on the speed of the astronauts' reaction time. This point is to be carefully rechecked during the training phase. Either astronaut will be able to launch the ejection seat by pulling a stirrup-shaped D-ring located near his hand. Either ring ejects both pilots. There will be no such thing as the captain electing to stay with his ship.

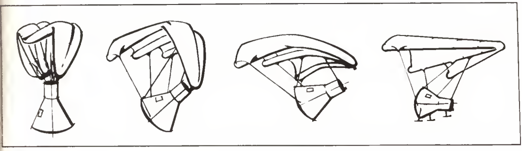
The ejection seats may also enable the space men to get out of the capsule and move around a little in space while in orbit. Such ventures will probably be limited to fifteen minutes and, of course, to one man at a time. These exits are made possible by the fact that the ejection seats require hatches that will open without detaching from the spacecraft.

It may be possible for the two astronauts to open their hatches in orbit and allow the cabin to depressurize. With the hatches open and snubbed back the pilots could stand up and peer outside or even venture out a little way into the abyss. A crucial factor in deciding whether or not this will really be done in Gemini will be the progress of space suit design.

The Gemini will be lofted into orbit by one of the nation's newest and most potent rockets, the Titan II intercontinental ballistic missile. It is a second-generation device, more powerful than either the Atlases that have launched the Mercury capsules or its own direct ancestor, the Titan I.

The chemical fuels used for the Titan II are believed incapable of explosion on contact. The relatively slow rate at

Paraglider, or Rogallo wing, is an inflatable device that will replace parachutes previously used to lower manned capsules after re-entry into the earth's atmosphere. The device is being developed for use in bringing down two-man Gemini craft and may be adapted for Project Apollo if it proves worthy. The sketches below show how it is deployed.



which they would burn, even in the case of disastrous failure on the launching pad, is another factor permitting the use of ejection seats.

The rocket-fuel oxidizer is a caustic compound called nitrogen tetraoxide. The fuel with which it combines is a blend of hydrazine, a common rocket fuel, and a related compound called UDMH (unsymmetrical dimethyl hydrazine). The fuel burns much more cleanly than do less sophisticated propellants, but because these are caustic, poisonous compounds, the ground crews will have to wear special protective suits.

At the end of a Gemini mission the adapter will be broken free. The spacecraft will make its meteor-like re-entry into the earth's atmosphere in a manner that has become familiar through the Mercury program. The Gemini spacecraft will have a slightly offset center of gravity. This arrangement will allow for a little lift and the possibility of controlling somewhat the re-entry course.

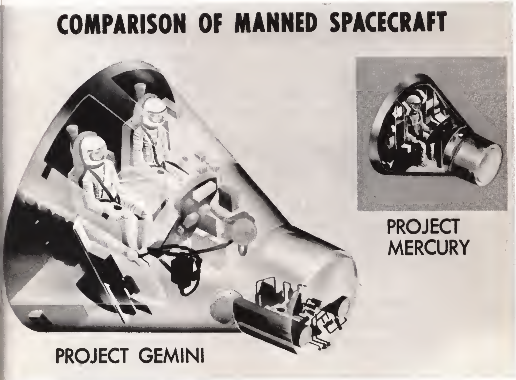
It is after re-entry that the great innovation in the Gemini design and function is to come. A system is being developed now that will eliminate the huge landing parachute that brings the Mercury capsule back to the earth for a water landing. Instead, Gemini designers hope to use a device called a paraglider or a Rogallo wing, named after Francis Rogallo of Langley Research Center who pioneered the idea.

In essence this is an inflatable airplane wing that can be stowed in a ten-cubic-foot canister. Rodney G. Rose, whose province in the Gemini project is escape, landing and recovery, has called the paraglider the ultimate in parachute design. "What we have virtually done with the paraglider," he says, "is to transform the landing problem of a manned spacecraft from something out of the ordinary to something ordinary—the landing of a light plane."

The system is being tested by air-dropping half-scale models of the Gemini. Later, astronauts will actually get the experience of piloting paraglider-equipped capsules to

landing. Space agency officials hope to use the paraglider for all Gemini flights after the first unmanned launching. Its use will allow the pilot to pick his landing spot within a circle of roughly 40 miles after re-entry. The Gemini spacecraft will land on three skids, touching down on almost any relatively flat land surface at a speed of about 45 miles an hour and coming to a stop in ten seconds after sliding about 200 feet. The paraglider flight itself will last about thirty minutes.

Gemini missions are expected to start out approximately where Mercury leaves off, with a one-day orbital flight. The program will work up flexibly to the full two-week mission. There may be four or five long-duration flights, according to



Artist's concept showing relative sizes of Mercury and Gemini capsules.

present plans. Most of the rest will be concerned with the vital rendezvous problem.

When the Gemini, in its turn, gives place to Project Apollo, American astronauts will have learned many of the basic skills and proved many of the techniques with which to reach for the moon.

WALTER SULLIVAN

Spaceport U.S.A.

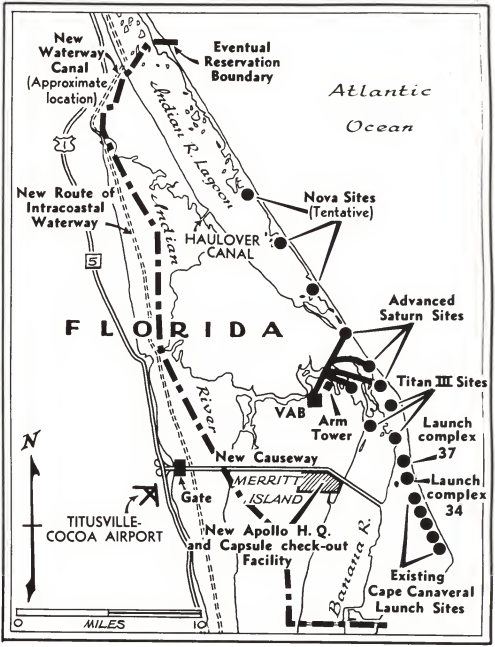
Work has begun on the first interplanetary travel station—at least in the Western world.

It will bear no resemblance to Grand Central Station or New York International Airport at Idlewild. It will be spread out along 25 miles of the Florida coast north of the present missile test center at Cape Canaveral.

Its key structure, at least during Project Apollo, will be a gargantuan hangar capable of housing, at one time, six rockets, each taller than the Statue of Liberty. Known as the Vertical Assembly Building, or V.A.B., it will represent a radical departure from current rocket-launching procedure.

In the past all big rockets have been assembled on the pad, or platform, from which they were to be launched. A pad was committed to one particular rocket, not only during its assembly, but also during the long clean-up period that follows each launching. The vehicles were subjected to all of the vicissitudes of the humid and sometimes stormy Florida weather.

The vehicles that will carry a succession of three-man expeditions to the moon or its vicinity will be assembled in



First Spaceport: Interplanetary travel station will be built along a 25-mile stretch north of Cape Canaveral. It will require rerouting of the Intracoastal Waterway and construction of vast launching sites for moon flights.

the V.A.B. on movable platforms. On the same platform, alongside each rocket, will be its own service tower. At the end of the indoor phase of the countdown a gigantic crawler, like a turtle with a back as large as a baseball diamond, will creep under the platform and carry it to the launching site. On the way a stop will be made at an arming tower, where igniters and other explosive components will be put in place.

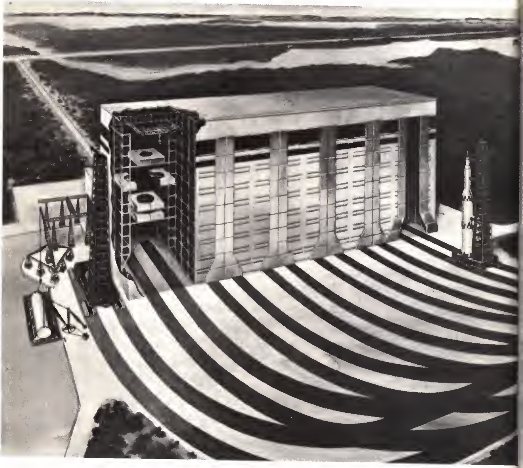
The crawler will be an adaptation of what is said to be the largest movable machine in existence: a stripping shovel developed by the Bucyrus-Erie Company of Milwaukee for mining coal. The shovel rides a platform carried by a squad of gigantic tracks. In Apollo the crawler will have to carry 2,500 tons, including the rocket, its platform and service tower.

The new launching method will make it possible to send up a series of Apollo rockets in quick succession, including some, if necessary, on rescue missions. If one vehicle proves defective, another can easily be substituted.

Both the rocket and its tower will ride upright across what is now a lagoon frequented primarily by pelicans, fishermen and water skiers. When the spaceport goes into operation, about 1965, only the pelicans will be allowed into the area. Soon thereafter the Intracoastal Waterway, chief highway for small boats from Maine to Miami, will have to be rerouted. This will necessitate the building of a canal at an estimated cost of $5,000,000.

The entire launching area is short on solid ground. Present plans call for construction of the Vertical Assembly Building on Merritt Island, in the lagoon on the inland side of Cape Canaveral. The building would be linked to the four Apollo launching sites by a broad causeway across the water and swamps. At each site the causeway will rise, on a ramp, to allow room below for the flames and hot gases ejected at launching. The crawler will move clear before the end of the countdown.

Merritt Island is some 30 miles long and is rich in fruit groves. Most of it lies within the 88,000 acres to be acquired by the National Aeronautics and Space Administration for its spaceport. The initial tract is 73,000 acres, with 15,000 additional acres to be acquired later.



The Vertical Assembly Building, as visualized in this drawing released by NASA, will be a monster, six-rocket garage, capable of assembling and servicing rockets taller than the Statue of Liberty, each mounted on a movable platform with its own service tower.

The reservation will extend from the Missile Test Center at Cape Canaveral north almost to Oak Hill, embracing much of the land between the Indian River and the sea. The new canal will pass near Oak Hill, replacing the Haulover Canal on the present Intracoastal Waterway.

The first step, in construction, already initiated, is "surcharging" the site for the Apollo Spacecraft Assembly and Check-out Facility on Merritt Island. Surcharging is the heaping of fill onto swampy land to squeeze the water out and make a solid base for foundations.

The facility will be the garage for the bug and other modules. Tests needed to make sure they operate properly will be carried out there. The site will also serve as headquarters for Apollo activities at the entire installation. The great size of the reservation is dictated by the need for wide separation between launching pads and for a broad no-man's land around any one of them at launching time. The four Advanced Saturn positions, from which the first Americans will be sent to the moon, must be separated by more than a mile and surrounded by a safety zone of three-and-a-half miles' radius.

The safety zone's size is dictated by the range at which the roar of the engines, on take-off, will reach 120 decibels.

The three northernmost launching sites, earmarked for Nova rockets, will be surrounded by a safety zone of eight miles' radius. Although these rockets have not yet been designed, it is expected that they will use nuclear-powered upper stages. It is this that has dictated very large safety areas.

One of the problems troubling planners of the spaceport is how to bring in the rockets that will themselves dwarf the Advanced Saturn vehicles. They arrive by water, and a canal may have to be dug to get them as close as possible to their assembly building, where the upper stages of each vehicle

A giant crawler (right) will carry the platform, on which are riding an Apollo vehicle and its service tower, to the launch site. It will climb a ramp sufficiently high to allow space below for the escape of flame and gas on blast-off.

will be checked in adjacent structures before being hoisted atop the massive first stage.

Perhaps even more serious than the handling of monster rockets is bringing in all the sand, gravel, cement and steel needed for this billion-dollar project. It is said that the building of each Apollo launching complex will be a more elaborate construction job than anything undertaken heretofore in the state of Florida.

The project calls for construction of a new causeway linking the mainland with Cape Canaveral and crossing Merritt Island alongside the Apollo headquarters area. This highway will end, on the coast, near Titusville-Cocoa Airport, which may become the chief port of entry for the huge NASA installation.

The leg of the coastal highway near the airport is being rebuilt with a cloverleaf connection to the new causeway.

At the north end of the existing facilities on the Cape, is the newly-built Launch Complex 37. This is to be used for launching the Saturn C-1 rockets that will test various Apollo components. Its nearest neighbor is Launch Complex 34, from which the first Saturn C-1 first stage was successfully fired in October 1961.

Launch Complex 37 has a single blockhouse and one gantry, but two pads. This is to speed up the tempo of launchings. After each shot, it takes a week or two to repair the blast deflector, replace and check out damaged hydraulic or electric lines, clean up the burnt plywood and other debris and repaint the facility. With two pads this delay is eliminated.

North of Launch Complex 37 a triangle of three sites has been selected for launching Titan III boosters that will hurl Dyna-Soar space gliders into orbit. The Advanced Saturn sites, from which the American moon explorers will be launched, lie still farther north. Beyond them are the three tentative Nova sites. The Nova, still on the drawing boards,

Bucyrus-Eri

Crawler Model: The platform carrying the Apollo rocket and its service tower will ride to the launching site on this movable platform on which a gigantic coal-mining shovel is mounted. Man at right indicates the scale.

will probably be comparable in size to the Washington Monument, which is 555 feet high and 55 feet broad at the base. It will be used for journeys to the other planets and for second-generation exploration of the moon.

GLADWIN HILL

Journey by Phonebooth

Three men are nearly 350 feet in the air—atop the largest rocket the United States has been able to devise. They are strapped in reclining metal chairs, three in a row, like three men in a twenty-first-century barber shop. But over their faces are complex space masks, not steam towels. The countdown for the Project Apollo flight has been dinned into them by repetition upon repetition. The suspense is almost unbearable.

Thus, one day within the present decade, three Americans will poise on the verge of mankind's greatest undertaking—a journey to another body of the solar system. How will they make the historic trip? The chamber in which the three astronauts will attempt a 500,000-mile two-week journey to the moon and back is taking shape in the space ateliers of California. It will have little more floor area than a pair of telephone booths. And about as much head room as a child's wigwam. The three men will be able to move about—but just. The vehicle in which they will hurtle through space is coming into existence on the floor of the sprawling factory of North American Aviation in Downey, a Los Angeles sub-

urb. There on the broad expanse have been assembled cone-shaped, full-scale facsimiles of the Project Apollo command module—the home-away-from-home of the three American moon men. Like artisans working on a house, technicians have hammered together dozens of plywood and metal mock-ups of a strange vehicle. The wigwam shape of the space cabins has given the factory area the nickname of "Teepee Village."

Plywood mock-ups are being used in many preliminary phases of the gigantic undertaking. They are representations in size and volume which enable the teams of space engineers to cope with internal equipment and with such basic problems as transporting the capsules across country for tests—and the ultimate take-off into space.

Metal models simulate shape and weight—for drop tests, into water and onto the ground. These tests are getting under way now. They will be used in rocket launchings that will be made in 1963.

The command module stands 12 feet high and 13 feet in diameter at the bottom. It is not much bigger than the Mercury spacecraft, which stands 9½ feet high, 6 feet across the bottom. The size was dictated partly by the need for a streamlined fit against the rocket that will hurl the craft into space; partly by the minimum estimated weight and space requirements of the three intrepid men who will make the voyage; and partly to achieve the best configuration for re-entry.

The three men will not stay strapped in couches throughout the trip. They will be able, after launching, to climb out of their space suits for the time being. They will move about, perform their navigational chores and flex their muscles to keep them in tone.

A 13-foot diameter may sound spacious. But that is only at the bottom. Allow for the sharp tapering sides and the wall thickness necessary to withstand stresses and to house vital

equipment—then the remaining space is about equal to that of a chamber only 6 feet long, 6 feet wide and 6 feet high. "Oh, no!" one of the Apollo scientists protested when this was suggested. Then he did a quick calculation. And it came out to considerably less space than a 7-foot cubic room.

This command module will be the uppermost of three units making up the 55-foot-long, 43-ton spacecraft that hurtles toward the moon, after the spent launching rockets and the escape tower fall away following take-off. The command module will weigh about five tons. Immediately below it will be the service module, and beneath that, as the assembly stands atop the booster rockets on the launching pad, will be the bug.

The bug will be left orbiting the moon, and the service module will be jettisoned as the spacecraft approaches reentry into the earth's atmosphere.

The astronauts will have to slow down by "flying" the command module on a sloping course, down through the atmosphere, for a distance of 3,500 to 6,000 miles, depending on where they land. A cone is not much like an airplane but you can maneuver it to some extent by shifting its center of gravity.

North American Aviation has the prime contract for the Apollo command and service modules. By mid-1962 about 2,500 scientists, engineers and skilled technicians were working on the project at the Downey plant under the direction of Harrison A. Storms, Jr. He is the youthful, quizzical engineer who guided the revolutionary X-15 rocket-plane project to its successful consummation. Some 4,000 persons will be involved when the engineering effort hits its peak around the end of 1963.

Every week or two, top engineers and administrative officers of NASA's Apollo headquarters in Houston fly to Los Angeles for a progress and planning conference at North American. Members of the astronaut team participate in

these meetings and visit the factory for technical consultations. North American has representatives at subcontractors' plants across the country, and the subcontractors have their men at North American. This is necessary because the precise integration of each piece of equipment with all the rest is so critical. The multifarious organizations and individuals working on spacecraft segments are going about their jobs as calmly and methodically as if they were manufacturing soap.

Simulated Space Cabins: Mock-ups of the craft in which astronauts are to ride to the vicinity of the moon are being produced in quantity at the Downey, California, plant of North American Aviation. They are full size and aid planning of equipment.

Most of the protracted task falls, in their wonderful jargon, "within state-of-the-art parameters." Parameters are the factors that must be considered in any given problem. What they mean is that the job calls for no miraculous engineering inventions or discoveries. Technically, it will be a logical progression from the Mercury work and forthcoming Gemini two-man orbital project.

The main spacecraft problems transcending the preceding ventures are two: to produce equipment to serve on a scale of weeks rather than hours; and building into every bit of it the 99-plus per cent reliability necessary to reduce to a minimum the risk of losing good men between here and the moon and wrecking a multibillion-dollar undertaking.

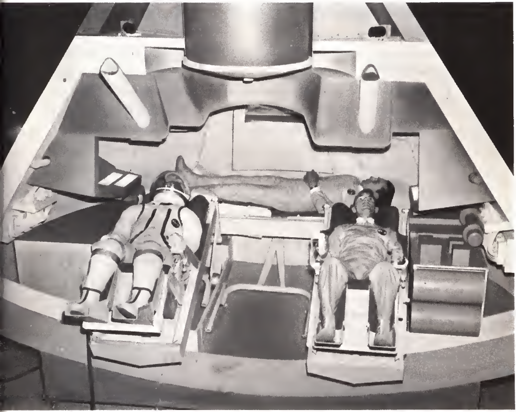
The planners have satisfied themselves that a spacecraft without any outlandish innovations can withstand the stresses of launching and such hazards of travel as meteoritic particles and normal radiation.

Established steel and aluminum alloys are contemplated for the hull of the spacecraft, in double wall "honeycomb" construction several inches thick for strength. The craft's water supply may be stored in a thin "curtain" in the walls, since water is a good insulator against radiation.

The toughest structural problem is the heat shield at the bottom of the conical command module. It will have to dissipate heat up to several thousand degrees Fahrenheit that will accumulate over a long interval compared with the Mercury capsule's quick re-entry. This is because the Apollo craft will re-enter on a slanting trajectory. Coming from out in space, its re-entry speed will be 25,000 miles an hour, compared with the Mercury orbital re-entry speed of some 17,600 miles an hour. The dissipation will be accomplished by a layer of specially compounded plastic that will slough away in the process. Achieving a positive shield is expected to require much experimentation and testing.

On launching, the three astronauts will be reclining side

by side on hinged seats much like reclining barber chairs. Their backs will approximately parallel the floor of the cone. The one designated as the scientist-engineer will be in the middle, with the pilot on his left and co-pilot on his right, according to the present plan. The center seat will be movable, so that in flight it can be shifted to the back of the cabin to serve as a bed and provide a little moving-around space. There will be navigation controls on the seat arms.



North American Aviation

Space Roomette: Present plans for the copsule in which three men will ride to the vicinity of the moon provide that they take off obreost. However, one seot con be shifted to the reor, permitting one man to sleep on the long journey. Capsule shown is a model.

Instrument panels and additional controls will be on the wall confronting the seats. There will be thick glass windows, plus periscopes.

Headroom in the cabin will be limited, both because of its sloping sides and because the man-sized airlock for transfer into the bug will slant down from the apex. A compartment surrounding the airlock will contain the re-entry landing parachutes or, if Gemini tests work out, the inflatable paraglider (Rogallo wing).

The airlock is a small passageway that will let astronauts get in and out without releasing the cabin pressure into the near-vacuum outside. When an astronaut climbs into the airlock, the inner door will be sealed, so that he can open the outer door. If the cabin pressure of seven pounds a square inch—equal to the atmospheric pressure 19,000 feet up—should be released by an accident such as puncture, the astronauts will be dependent on their space suits for survival. The weightlessness the astronauts will experience during most of the trip, while it may be a physiological problem, is not considered a mechanical problem in the cabin. The space is so small a man will always have something to brace against.

The main machinery in the command module will be guidance computers, communications equipment and small steering rocket units. There will also be an independent breathing and pressure system for re-entry, after the service module has been jettisoned. Body wastes will be stored.

The major items of engineering equipment for the long haul to the moon and back will be in the 23-foot-high service module. These will include the fuel-cell power generator; the main pressure-atmosphere system; the inflight rocket propulsion units and fuel, and stabilization rocket engines.

The exotic fuel-cell power source will serve an important secondary function. Chemical reactions will not only produce electricity but will also combine hydrogen and oxygen into pure water—part of the astronauts' drinking supply.

Not until the summer of 1962 did the space agency decide on the bug-ferry approach in preference to landing the entire spacecraft on the moon. Details of the bug accordingly are still indefinite. But its main components will have to include a pressure-atmosphere system, communications, guidance rockets, retro rockets for landing brakes and a launching rocket engine to get it back into lunar orbit for reunion with the main module.

Probably never, in the history of mankind, has so much care gone into the design of a vehicle as is being lavished on the craft—the bug and its parent command module—that will initiate manned exploration of the solar system.

WALTER SULLIVAN

Tracking and Communications

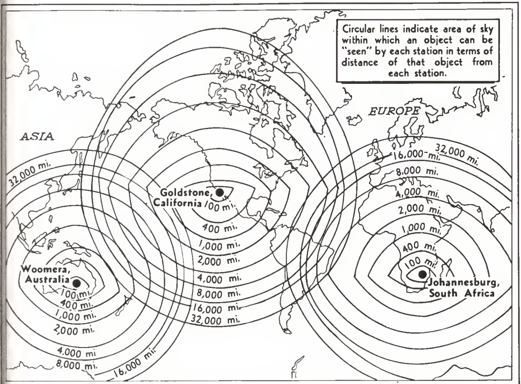
Nothing would be more agonizing for the men of Project Apollo than to send three men hurtling toward the moon and then to lose track of them. To prevent this, intensive preparations are being made for a tracking and communications system that will be as foolproof as possible.

The communications blackout after the orbital flight of Commander Scott Carpenter, as his capsule re-entered the atmosphere on May 24, 1962, is an example of the kind of problem that must be solved. When three astronauts return from the moon, their re-entry will be far more prolonged and severe.

In the words of one scientist working on the communications problem, the lunar astronauts will enter the atmosphere at a "screaming velocity." Because their speed will be about 25,000 miles an hour, they will enter the upper air at an extremely low angle to reduce their rate of retardation and hence the extent of heating. The resulting ionization, or electrification, of the air by the plummeting vehicle will be far more prolonged and severe than it was with Commander

Carpenter. It is this ionization that cuts off radio communications.

The Apollo re-entry will occur along an arc spanning the Pacific Ocean, bringing the capsule down into the lower atmosphere as it reaches the West Coast. The vehicle would then land in a desert area of the Southwest.



Deep Spoce Trocking Network: Three greot, dish-shaped radio antennos, in Australia, Californio ond Africo, will keep in touch with vehicles going to ond from the moon. Despite the earth's rotation, ony Apollo vehicle should be "within sight" of one station except when it is behind the moon. As shown obove, the horizon ot eoch station limits its coveroge when o vehicle is close to the earth. The network is olso blind over the poles, but no lunor vehicles ore expected to fly into those regions.

To help bring the capsule down safely, it is planned to span the Pacific with tracking ships. The path of the vehicle, as it enters the atmosphere, must lie within a channel only 40 miles deep. For a space craft traveling at 25,000 miles an hour from a starting point some 240,000 miles away, this is a supreme feat of marksmanship. It is hoped that the tracking ships will help to automate the re-entry process. Two such vessels are now used on the Atlantic Missile Range and two on the Pacific range. At least three others are under construction.

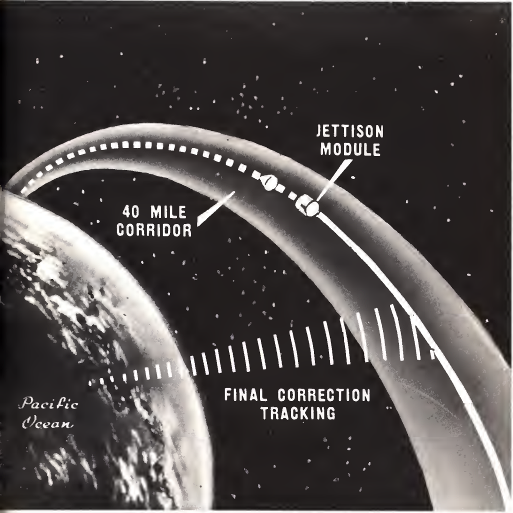
NASA has sought to learn from the Pentagon to what extent these ships can be counted on to aid in Project Apollo. It may be that NASA will have to convert some war-surplus cargo ships into its own tracking vessels.

According to present plans, contact with the astronauts and their vehicles in the vicinity of the moon—and on it—will depend on the three existing stations of the Deep Space Instrumentation Facility. They are so located around the world that at least one can always aim its antenna at a vehicle on the way to or from the moon.

The sites are at Goldstone, California, Johannesburg, South Africa, and Woomera, Australia. They cannot cover the entire heavens. However, their only blind spots are in areas far beyond the reach of any vehicle going to and returning from the moon. Each is equipped with an 85-foot, dish-shaped antenna that is considered adequate for the project as long as all goes well. However, a 210-foot antenna projected for Goldstone will be able to hear signals from a vehicle whose directional antenna is inoperative. In such a case, the vehicle would have to broadcast on an antenna that dissipates its power in all directions and hence can send only a very weak signal to a point 240,000 miles away.

Meanwhile, the method for sending information from a space vehicle to the ground is being improved in a manner that should greatly speed the processing of data. The tech-

nique used to date depended on frequency modulation, whereas in the future it will depend on the use of pulse-code modulation. The effect will be to make it possible to wire the incoming information directly into a digital computer.



Return to Earth: When astronauts return from the moon, their re-entry into the earth's atmosphere will be a long descending arc spanning the Pacific. Their safe return will depend on tracking by the ships below.

The new system will first be used for Project Gemini, the orbiting of two men around the earth, and will probably require one or two tracking ships at strategic points in the large ocean areas.

The communications traffic jam that will occur, when Apollo goes into full swing, will be formidable because a considerable number of unmanned Surveyor vehicles will already have landed on the moon with instruments whose readings will be broadcast to earth. Similar vehicles will be placed in orbit to send television pictures of the lunar surface for mapping, as well as extensive scientific data. Finally, the Apollo astronauts themselves will land and emplace instruments.

To avoid having all these stations, in or near the moon, talking at the same time, it will probably be necessary to command their broadcast schedules from the earth.

The elaborate systems of tracking and communication being devised for Apollo typify the changes in the nature of exploration that have taken place in recent decades. When Captain Robert Falcon Scott set out for the South Pole in 1911, he cast off all contact with the world. The plight and final agony of himself and his four companions did not become known until their frozen bodies were found a year later. The Apollo astronauts will be in touch almost every moment of their far longer journey. Even such conditions of their spacecraft as temperature and humidity will probably be radioed to earth automatically. Not for a moment should there be any uncertainty as to their whereabouts and their fate.

ROBERT K. PLUMB

Perils of the Abyss

When the launching rockets cut off as the first Apollo spacecraft hurtles toward the moon, three men will be carried into an environment incredible, empty, silent and perilous.

No human being has yet ventured into the fearsome region beyond protection of the earth's magnetism. None of the Soviet or American astronauts has penetrated so far.

How will the moon men survive? How will they react, live and work? Today, in the great laboratories and test chambers of Project Apollo, answers to these questions are being worked out.

Since life evolved on earth, two great shields have stood between that life and the radiation, meteors and other perils of space. The astronauts have surmounted only one of those shields to date—the atmosphere. Still above them lies the magnetic field of the earth. Trapped within that field are a host of high-energy particles. These constitute the Van Allen radiation zone. This could harm someone who remained within the region for many hours, as for example in an orbit around the earth higher than those for the early astronaut flights. It probably does not present a serious hazard to the moon traveler.

The lines of force within that magnetic field also have a protective function. They deflect the far higher energy particles, or cosmic rays, that rain upon the earth from all directions. Occasionally, when there is a major eruption, or "flare," on the sun, an enormous mass of these particles is hurled toward the earth. Most of them are protons, or the nuclei of hydrogen atoms. They may have enough energy to pierce feet of lead, but they cannot cut across the force lines of the earth's magnetism. Hence, a man in orbit below the Van Allen zone is safe. A traveler above it is not.

The atmosphere itself has served to protect us from the constant rain—and occasional downpours—of meteoric particles. The bigger ones, comparable to large grains of sand, burn up in the air as shooting stars. The smaller ones are retarded and sift down to earth as invisible dust. Rocket and satellite observations in recent years have disclosed, at first hand, clouds of this interplanetary dust.

It is known, as well, that chunks of nickel-iron occasionally fall to earth as fireballs and meteorites. There have even been asteroids—though they are few and far between—whose diameters are measured in miles. What are the chances that a vehicle on the way to the moon and back will hit a rock in space? They seem to be so slight as to be negligible, alongside the other hazards of the journey. However, the steady impingement of much smaller particles may be more of a problem.

Shortly after Colonel Glenn circled the earth in February 1962, part of the Atlas rocket that propelled his capsule into orbit fell in Africa. It was peppered with cavities in a manner that startled American scientists. There were conferences and debates as to whether the Atlas ran into a cloud of small meteorites. The skeptics believe the pitting was a by-product of the rocket's partial disintegration on re-entry into the atmosphere.

Nevertheless, the danger that, on prolonged space flights,

the skin of a vehicle might be eroded by interplanetary dust is still considered a cause for concern. The available evidence concerning the amount of debris in space was reviewed in a paper recently prepared by scientists at NASA, using both American and Soviet data.

They pointed out, for example, that in 1959, during the eighty-day lifetime of experiments aboard the American satellite Vanguard III, more than 6,000 impacts by small particles were recorded. Of these, some 2,800 occurred in a seventy-hour period from November 16 to 18. This was also the time of the Leonid meteor shower. The Leonids are one of the two best-known annual displays of meteors, or shooting stars. The others are the Perseids that occur in August. Both seem to represent the passage of the earth through debris left by the passage of a comet. The showers are named for the constellations from which they seem to emanate.

Not all the particle clouds encountered by space vehicles have been associated with meteor showers visible on earth. Explorer I, the first American earth satellite, ran into what seems to have been a cloud of interplanetary dust on February 2 and 3, 1958. The conclusion of the analysts was that there are large fluctuations in the density of particles. The cosmic dust falling to earth is predominantly in grains weighing less than one-millionth of a gram. A conservative estimate of this accretion, according to the report, is 10,000 tons a day.

On the other hand the utter emptiness of space is another problem for those planning Project Apollo. The vacuum is such as to cause every cell of the body to explode. The astronauts, therefore, must be given an atmosphere adequate for breathing, but the equipment must not be burdensome.

Because the first astronauts will land on the moon during the two-week lunar day, the temperature of the surface onto which they step will probably be close to 260 degrees Fahrenheit. However, the environment will be considerably different from that on a city street "hot enough to fry an egg." We

feel the heat of the pavement in two ways: by conduction and by radiation. Heat speeds up the motions of atoms and molecules. This agitation spreads through a substance because of increased molecular collisions. This is known as conduction.

On the moon there is no air and hence there should be virtually no conduction, except through an astronaut's feet. The radiated heat impinging on his space suit, however, both from the naked sun above and from the torrid surface below, will be searing. Hence, the lunar astronaut will probably carry a back-pack cooling system.

Medical specialists regard solar flares as the most unavoidable hazard. Luckily only certain of these flares, or eruptions, throw out lethal bursts of particle radiation. The existence of this hazard was not recognized until a particularly severe eruption occurred on February 22, 1956, but several of great intensity have been observed since then.

The frequency of solar flares follows the eleven-year sunspot cycle. But it is not yet certain that this is true of the hazardous type. Hence it is not possible to predict the chances of such a flare with much accuracy. It is hoped, of course, that this prediction capability may be improved by the time of the first manned flight to the moon. Meanwhile, it may be possible to give a few minutes' warning. The dangerous flare emits a peculiar radio noise that reaches the earth shortly before the lethal particles do.

The last sunspot maximum occurred in 1958-59 and the next minimum is expected in 1964-65. The latter period has been given the romantic title of International Year of the Quiet Sun and has been set aside for intensive observations. These will be compared with those made during the International Geophysical Year of 1957-58, when the sun was speckled with spots, and flares were frequent.

The United States is expected to make its first attempt to land men on the moon between 1967 and 1970. By the latter date the sun probably will be highly active. Even then, how-

High Altitude Observatory

The chief hazard to prolonged space journeys is a tendency of the sun periodically to shoot out streams of extremely high energy particles. This photograph was obtained by blocking out all but the sun's rim.

ever, the chances of a lethal flare's occurring during a week-long round trip to the moon, more than 200,000 miles from earth, do not seem very great.

There are many other forms of radiation in space, including those that span the entire electromagnetic spectrum from radio waves through infrared, visible and ultraviolet light, X-rays and gamma rays. Cosmic rays are not rays of light. They are high-energy particles, a small percentage of which have sufficient energy to pierce the earth's magnetism and atmosphere. About 10,000 of them hit every square yard of New York City per second. This is part of the natural radiation of our environment.

At very high altitudes cosmic rays have caused graying of hair in experimental animals. At least one balloonist was similarly affected. From what we know now, however, it appears that cosmic rays do not damage the body in lengths of time such as that planned for the Apollo flight.

The Apollo vehicle will, it is hoped, provide adequate shielding against most flares. Construction material, skin thickness, arrangement of equipment in the vehicle—all will be designed for maximum protection. On the way to the moon, sun-seeking equipment will keep the axis of the vehicle pointed toward the sun. This should provide some protection. However, the particles ejected by a flare follow a curved path. It is not possible at present to predict to what extent they would strike the vehicle from the side, or even from behind. If the men work outside the spacecraft, they will retreat to it when warned from the earth that a flare has occurred.

The problem of weightlessness became of increased concern after it was announced by the Russians that Major Titov, in his seventeen-orbit flight in August 1961, felt ill after the first few orbits.

Weightlessness occurs when the force of gravity is neutralized. Gravitational and inertial forces, acting on a vehicle and its passengers, cancel each other out. This is true of any

object in free flight, whether it be falling to earth, flying to the moon or in orbit. The phenomenon is experienced, to some extent, by the passengers in an elevator that descends suddenly. It can be achieved, for up to one minute, by zooming high-speed aircraft into upward arcs.

Major Titov apparently became ill on his sixth orbit. Hence, Apollo medical men are particularly interested in observing American astronauts who make six or more orbits.

However, the flights of the Soviet astronauts Nikolayev and Popovich, in August 1962, suggested that Titov's experience may have been due to a personal idiosyncrasy, comparable to a proclivity to seasickness. Nikolayev was in orbit around the earth for ninety-five hours and Popovich was up for seventy-one hours. According to Soviet accounts, neither suffered any ill effects, but if weightlessness does prove to have some insidious effects that cannot be controlled by pills or other countermeasures, it may be necessary to provide artificial gravity in the spacecraft by rotating it.

If artificial gravity is needed—and gravity like that at the surface of the earth could be achieved by rotating a space vehicle of 15-foot radius every 4.5 seconds—then the question arises how much gravity is essential. Should designers try to duplicate the gravitational field of the earth, or should they select the gravitational field of the moon, which is one-sixth that of the earth?

At the time of this writing, the problem of human relations has not arisen in space travel. The orbits flown by American and Soviet astronauts have all been solo flights. In the Apollo program a three-man team must be meshed to accomplish what will at best be a very difficult mission.

Some psychologists believe that a three-man crew would not be as stable as a two-man crew. Two of the three men might form an alliance excluding the third.

Some experience with two-man crews has been attained in the two-man space cabin simulator of the Air Force School

of Aerospace Medicine at Brooks Air Force Base, San Antonio, Texas. The purpose of the experiments is to study reactions in space cabin atmospheres in preparation for Projects Gemini and Apollo.

The Gemini cabin will contain 100 per cent oxygen at a cabin pressure of five pounds a square inch. The Apollo cabin will probably have an atmosphere half oxygen and half nitrogen at a pressure of 7.35 pounds a square inch, about half the atmospheric pressure of the earth at sea level.

It has long been known that man cannot breathe 100 per cent oxygen at normal atmospheric pressure for extended periods without toxic reactions. However, if the pressure is reduced, oxygen breathing becomes more acceptable. In the Gemini and Apollo spacecraft, lowered pressure would also simplify design.

In the experiments at Brooks, volunteers lived inside space cabin simulators with artificial atmospheres. They followed a daily pattern of work and sleep and had contact with the outside world only through dials and wires. One test lasted thirty days with crew members breathing 40 per cent oxygen and 60 per cent nitrogen at a pressure equivalent to that at 18,000 feet altitude. Other tests lasted for sixteen days with the two-man crew breathing a 100 per cent oxygen atmosphere at a simulated altitude of 33,500 feet.

These cabin conditions resembled those expected in a space vehicle, with important differences. For one thing, there was no weightlessness. The two-man space cabin simulator was a hermetically sealed cabin containing all the necessary environmental control and life-support equipment except the heat exchanger and the power supply. Dehydrated and precooked meals were used. Water requirements were met by stored supplies and by waste water recycled during the simulated flight. The recycled water was purified by vacuum distillation. Urine, wash water and water condensed from the cabin atmosphere were used.

University of Minnesota

Deadly Blizzard: This film, suspended from a balloon, rode above most of the atmosphere after a solar flare. Lines were produced by protons (hydrogen nuclei) of extremely high energy. Film is magnified 300 times.

Blood, clinical chemistry, bacterial studies and eye and other examinations revealed no significant changes. Definite but mild changes in work capacity were found, and some changes in heart activity were noted, but they were brief. The most significant discovery was that few important changes in the volunteers could be attributed to the long tests.

RICHARD WITKIN

Moon Pioneers—Selection and Training

Astronauts training for lunar flights will be whirled in a three-man centrifuge, deposited on the sea inside capsule models, and sent as high as 5,000 feet atop a delicately balanced jet engine tilted to the vertical.

They will also spend hours in an assortment of less dangerous but no less vital trainers rooted firmly to the ground. They will simulate lunar missions in full-scale Apollo capsules plugged into computers and to the global tracking network. They will aim sextants at stars in changing patterns in a planetarium designed specially for practicing earth-to-moon navigation.

By the time the first Americans leave on a lunar journey, they will be flipping the right switches and cranking in the right course corrections almost instinctively. They will be familiar with every detail of their mission but the emotion that will grip them when they finally emerge from their craft and set foot on the lunar surface.

Much of the training equipment still is in the planning stage, but since the first lunar flight may be attempted as early as 1967, officials are rushing work both on the research

devices to develop optimum flight techniques and on the devices in which most of the astronaut training will be done.

Many observers predict that the captain in command of the first expedition will be one of the six astronauts in the current Project Mercury program of earth-orbit flights. They do so even though the youngest of these astronauts, Major Leroy G. Cooper, Jr., will be past forty years old.

The popular notion used to be that forty was far too old for a man facing the rigors, known and unknown, of a new thrust into space. But Colonel Glenn, who was forty when he became the first American astronaut to orbit the earth early this year, has changed a lot of people's minds. In fact, the engaging Marine is such a refutation of the popular notion about age and space flight, and appears so eager to push on to bigger things, that he could conceivably command the first lunar flight—at the age of forty-five or more.

The co-pilot for the Apollo moon shot may come from two new groups of astronauts. One, of nine men, was selected in September 1962, consisting of four Air Force officers, three Naval officers and two civilians. The second group is to be chosen in 1964. A total of 253 jet test pilots, both military and civilian, volunteered when the call went out for new astronaut candidates. An applicant had to meet these criteria: have experience testing jets either in the armed services, with the space agency or with the aircraft industry; have a degree in the physical or biological sciences, or in engineering; be an American citizen under thirty-five at the time of selection; stand up to six feet tall. The following were the 1962 selectees:

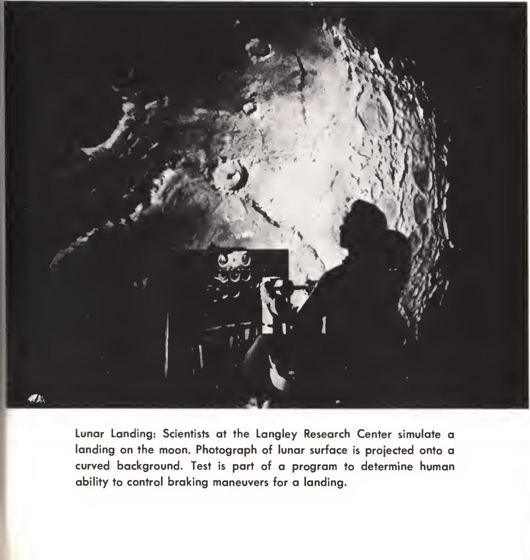
James A. McDivitt, 33, a Captain in the Air Force who recently served as experimental flight test officer at Edwards Air Force Base

Elliot M. See, Jr., 35, a civilian test pilot for the General Electric Company since 1949 except for service in the Navy from 1953 to 1956

Thomas P. Stafford, 32, an Air Force captain whose last assignment was chief of performance branch, experimental test pilot division, Edwards Air Force Base

Charles Conrad, Jr., 31, a Navy Lieutenant who once served as flight instructor and performance engineer at Patuxent Naval Air Test Center

Frank Borman, 34, an Air Force Major whose last assignment was as instructor in the Aerospace Research



Lunar Landing: Scientists at the Langley Research Center simulate a landing on the moon. Photograph of lunar surface is projected onto a curved background. Test is part of a program to determine human ability to control braking maneuvers for a landing.

Pilot School at Edwards Air Force Base

John W. Young, 32, Lieutenant Commander in the Navy who was program manager and test pilot for the Navy's F-4-H project

Edward H. White, 32, a captain in the Air Force who served as an experimental test pilot at Wright-Patterson Air Force Base

Neil A. Armstrong, 32, once a civilian test pilot at Edwards Air Force Base and one of three men assigned to fly the X-15 rocket plane

James A. Lovell, 34, a Lieutenant Commander in the Navy who has been a flight instructor and a test pilot at Patuxent Naval Air Test Center

The criteria used in these selections effectively ruled out women, since there are none, in this country anyway, who have tested high-performance jets. A House subcommittee was impelled to look into this absence of women in the astronaut program. The hearing did not produce any immediate changes in astronaut qualifications, but it did produce some quotable quotes.

Said Jane Briggs Hart, a pilot married to Senator Philip A. Hart, Michigan Democrat: "Let's face it! For some women, the P.T.A. is just not enough."

Said Jerrie Cobb, a woman pilot who has passed physical tests like those given male astronauts: "They won't let me take the actual training course, but I see they have a chimpanzee who is being trained to take it."

Said Jacqueline Cochran, probably the most famous woman pilot in the country: "Women will prove to be as fit as men for space flying, but such proof is presently lacking." She recommended medical research on the subject.

And Colonel Glenn said: "If we can find any women that demonstrate they have better qualifications for going into a program than we have, we would welcome them with open arms, so to speak."

Wide World

Space Mechanic: Engineer at the Marshall Space Flight Center, Huntsville, Alabama, studies special taals far use in space flights. He stands an a cushian af air that simulates the weightless enviranment of the spacecraft.

Research and training devices for simulating various phases of space flights fall into two main groups, those that move and those that do not. In the category of moving devices are those that will simulate lunar landings and take-offs. One such device will probably be put into operation in late 1963 at the Langley Research Center at Langley Air Force Base, Virginia. Trainees will take their places in a two-man capsule containing equipment similar to that on the two-man ferry, or bug, being designed to make the lunar landings.

The capsule will be suspended on cables that will exert just enough upward pull to cancel five-sixths the gravitational force of the earth. The one-sixth left will make the capsule seem to weigh what it will on the moon. Test pilots "flying" the simulated ferry will operate downward-thrusting rockets to ease themselves to a simulated lunar landing. They will maintain balance and move side to side with rockets facing in other directions. The actual lunar ferry will be controlled in similar fashion.

The simulator will move within an area about 200 feet high, 400 feet in one lateral direction and 100 feet in the other. It will be located at the Langley Research Center because its primary purpose will be research. Before astronauts can be trained in standard preferred procedures for gently depositing the lunar ferry on the moon and then taking off again, those procedures must be worked out in a careful research program that tests various alternatives.

Once the preferred procedures have been found, Apollo astronauts are expected to do a modest amount of preliminary training on the same device. But the full-fledged astronaut training course is expected to be given on a more realistic trainer being built for use, initially, at the space agency's Flight Research Center at Edwards Air Force Base, California. This will be a full-scale ferry model able to maneuver between the ground and altitudes up to 4,000 to 5,000 feet.

Cancellation of the five-sixths of earth gravity will be

accomplished in this case by a turbo-fan engine, turned tail-pipe down. As on the Langley device, down-thrusting rockets will counter the remaining one-sixth of gravity and ease the ferry to its landing, and other smaller rockets will provide lateral movement and balance. Like the Langley simulator, it also is expected to be ready for initial operation late in 1963.

At its new Houston center, the space agency plans to build a centrifuge able to whirl a three-man Apollo cockpit at speeds that will generate multiple-G (for gravity) acceleration and deceleration forces that might be encountered on a lunar flight. Unfortunately, it is not possible to simulate reverse conditions—weightlessness, or the apparent absence of gravity—for longer than a minute or so on earth. Apollo crewmen will gain experience with extended periods of weightlessness only on actual space flights, either in the Mercury program or, in the case of the new astronauts, in two-man Gemini vehicles.

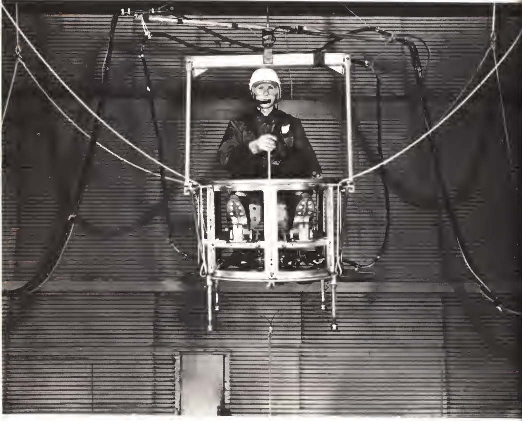
Machines are even being constructed so that astronauts can practice the complex rendezvous and docking of the lunar ferry and the mother craft in orbit around the moon. Two simulators for docking training are planned. One is being built by the McDonnell Aircraft Corporation, the prime contractor for the Gemini capsules. It should be delivered to the Manned Spacecraft Center in Houston early in 1963.

The simulator will consist of duplicates of a two-man Gemini capsule and of an Agena. Both will be mounted on rails. They will have a maneuvering distance of 100 feet head-on, and 40 feet vertically and laterally.

The other docking simulator will be built at Langley and will serve more for research than for actual training. The capsules will be on cables rather than rails, and will be able to maneuver in a wider variety of ways than the capsules on the McDonnell trainer.

Since Gemini capsules will make their landings back on earth suspended under inflatable paragliders shaped some-

thing like folded paper airplanes, training in maneuvering these devices to desired landing areas on earth may be afforded by a technique that harks back to World War II. Paragliders supporting partly equipped rough duplicates of Gemini capsules would be towed by airplane to an altitude of about 10,000 feet. The paraglider would then be released and the trainees inside would maneuver it to a landing. It is not unlikely that, if the paraglider system works out well in



Simulated Flight: Pilot flies an early model of a device to simulate a moon landing. Overhead cable supports five-sixths of weight. Remaining sixth, equal to lunar gravity, is countered by pilot-controlled airjet pointed down.

Project Gemini, it will be adapted for Apollo missions.

Current thinking calls for Apollo to deploy three parachutes and settle straight down. The flight plans for both Gemini and Apollo missions provide for the craft to come down on land—a significant change from Project Mercury in which water landings are standard. But since the earth is covered almost 70 per cent by water, there is a good chance that any Gemini or Apollo craft would come down on the water unintentionally. For training in getting out of a capsule that has come down at sea, space officials have decided to use full-scale models of both Gemini and Apollo craft.

In the category of nonmoving, or fixed-base, trainers, there are two main types. First there will be so-called mission trainers. These will be full-scale models of Apollo capsules in which astronaut teams will be able to simulate procedures, normal and emergency, for the entire portion of a mission between earth and lunar orbit. Such simulations will be conducted with the complete worldwide tracking and communications networks in operation.

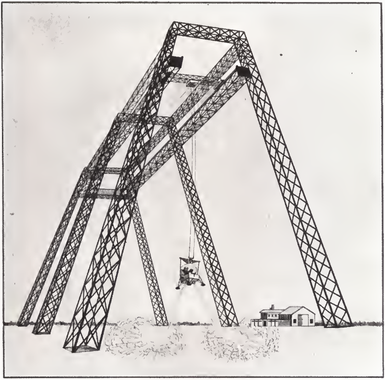
Another vital fixed-base trainer will be for navigation. A television-like device will project star patterns on the ceiling of the trainer for the three-man crews to shoot with their sextants.

Apollo planners say they have not yet solved how they will simulate the flight segments in which the lunar ferry travels from lunar orbit to the moon's surface and then back to the mother craft in orbit.

Mission trainers will be built both at Houston, where the control center for Apollo flights will be, and at Cape Canaveral, where the expeditions will be launched. The Gemini program will have similar mission trainers.

Thus will our first explorers of another heavenly body be trained. Influential scientists have urged that one man with scientific experience be included in the first pair who land

on the moon. They argue, for example, that a man who has spent years in geological work will recognize the significance of unexpected features of the moon in a manner beyond the ability of anyone else, no matter how well briefed. Certainly a scientist will land early in the Apollo program. He may already have completed graduate training in his specialty. He has probably flown many hours in high performance jet planes—perhaps as an Air Force reservist—and thus can be trained to do his share of the work en route.



Training Derrick: Artist's drawing of how finished device, to be built at the Langley Research Center, will look. It will be used chiefly for research into moon-landing techniques but will also help train Apollo astronauts.

WALTER SULLIVAN

What Will the Moon be Like?

What is the moon made of? Four hundred years ago Rabelais noted that some said the moon was made of green cheese. German peasants once thought the "Man in the Moon" was an exiled cabbage thief. More recently an astronomer said he had seen armies of insects migrating across the lunar craters. Today scientists seriously debate whether the moon's surface is like frozen custard or peanut brittle; whether it is pocked by jagged cliffs and treacherous peaks; whether its plains are endless wastes of powdery dust, or as one specialist has proposed, like an Afghan hound, with long, hair-like material. The answer will not be fully known until the first Apollo astronauts set foot on the lunar surface.

We are unable to find out from the earth, even with our largest telescopes, for our vision is blurred by the dust and turbulence in our atmosphere. We cannot see any lunar feature less than a half-mile long. The moon's terrain may prove to be beyond the most vivid imagination of earthbound writers of science fiction, and the scientific rewards of its exploration are incalculable.

Scientists cannot predict just what the astronauts will find, but they believe knowledge of our own planet will be vastly

enlarged. We should learn, for instance, whether the fearsome bombardment that has left the moon pocked with craters has gone on steadily during the moon's lifetime of four or five billion years or been spasmodic. From this we can estimate how often to expect similar impacts on the earth.

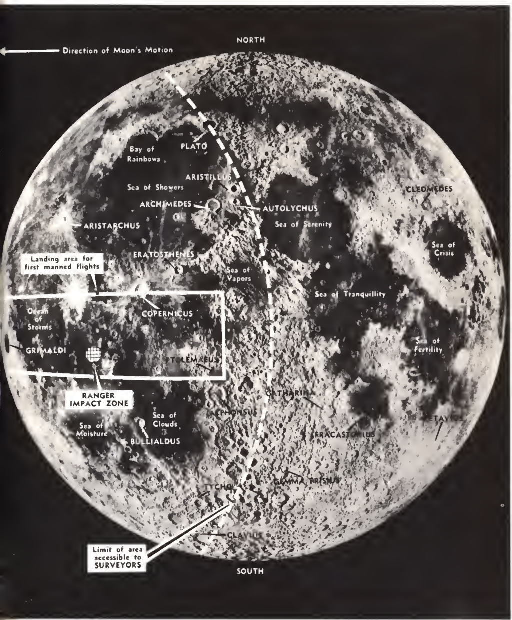
By sending unmanned vehicles we should be able to settle, in part, the controversy as to the nature of the lunar surface. Some authorities believe the moon will be incredibly hostile to astronauts: deeply crevassed, heavily blanketed with dust, deep in frozen foam or prickly with metallic whiskers. One Soviet astronomer has stated that he believes there is volcanic activity on the moon, and a volcano specialist has even suggested that the moon may be covered, at least in part, with Pele's hair, a product of Hawaiian volcanoes that is short-lived in an earthly environment (Pele is the Hawaiian goddess of fire). Warning that this idea is most controversial, a scientist associated with the moon project implored that no "shaggy moon story" appear in print.

The more conventional view is that the moon possesses a remarkably smooth surface, ideal for walking. However, no one knows. Some thirty-eight planned or proposed unmanned shots to the moon, in the next five years, should help settle the matter.

Despite the blurring effect of the earth's atmosphere, we can see sufficient craters and other evidences of fearsome events to assure us that the record on the moon is largely intact.

Because the moon has virtually no atmosphere, it has been spared the erosion that has repeatedly wiped clean the state of the earth's history. But the blurring prevents us from making out anything on the moon that is less than a half mile long. Hence our knowledge of its landscape details is dependent on such techniques as analysis of radar echoes and of sunlight reflected from its surface.

This limitation has led to divergent views on the lunar



Lick Observatory

Landing Sites: The first Americans on the moon will land within the rectangle enclosed by the solid line. It is 375 miles wide and 1,700 miles long, centered on the lunar equator. Its right boundary lies on the moon's central meridian, shown here shifted slightly to the left by libration, the twisting motion of the moon.

landscape. They are reflected in contributions to a text, *Physics and Astronomy of the Moon,* issued in 1962 in an effort to assemble what we know of the moon before man lands there. It was edited by Dr. Zdeněk Kopal of the University of Manchester in England and specialists from both East and West contributed to the volume, published by Academic Press.

In it Dr. Vassily G. Fesenkov of the Soviet Academy of Sciences says the moon's surface "exhibits the greatest similarity with models covered by deep holes with vertical walls and sharp edges." His view is based on observations of the brightness of various parts of the moon. It cannot, he adds, be covered with dust. He believes the surface to be "extremely porous." Others have suggested that the escape of lunar material into the surrounding vacuum and the effects of naked solar radiation have left a surface residue similar to frozen foam. A man stepping onto it would sink to an unknown depth.

On the other hand, Dr. Audouin Dollfus of the Paris Observatory believes the moon must be covered with a powder similar to volcanic ash. His concept is derived from analysis of the polarization, or alignment, of light waves after they have been reflected by various parts of the lunar surface. Like Dr. Fesenkov, he sees the surface as being riddled with cavities. However, he believes even the steep walls of these holes or clefts are covered with dust. He cites, for example, his observations of the Straight Wall in the western part of the Mare Nubium. This striking feature, 60 miles long, looks like a cliff some 800 feet high and as straight as a Midwestern highway. Light from this cliff is polarized in the same manner as that from nearby level areas. Hence Dr. Dollfus believes dust clings even to the steepest surfaces.

A few years ago it was suggested that the smooth, dark areas of the moon, known as seas, might be oceans of dust in which a space ship could vanish forever. This seems unlikely.

In the same volume, Dr. John V. Evans of the Lincoln Laboratory summarizes the results of radar echoing from the moon. His laboratory, attached to the Massachusetts Institute of Technology, has been a leading participant in this work.

Dr. Evans says radar echoes from the moon are similar to those obtained from sandy deserts by aircraft radar. He concludes that the moon is "smooth and undulating," with only 10 per cent of its surface covered by objects (such as boulders) too small to be seen from the earth.

These divergent concepts of the surface probably derive in part from the wavelengths observed. Light, with its very short wavelength, is affected by fine-grain structure. Radar echoes, being longer in wavelength, tell more about large features that might affect human mobility.

Dr. Kopal warns that the lunar landscape will not look like the pictures that illustrate science fiction. Photographs of the craters and mountains make them look extremely steep and rugged. However, photo-mapping techniques applied to the moon by Dr. Kopal and others in preparing lunar maps for the United States Air Force provide a different picture. They show that while some lunar mountains reach heights almost as great as Mount McKinley in Alaska, many look more like gently sloping hills.

The moon is so much smaller than the earth that the range of vision, or horizon, is far less. Thus, an astronaut standing in the center of the crater Clavius will be unable to see its walls. The walls are many thousands of feet high but at a distance of 70 miles, the radius of the crater, they lie beyond his horizon.

By good fortune the rectangular patch of the moon accessible to first manned landings adjoins its most interesting crater. This is Alphonsus, where, on November 3, 1958, and October 23, 1959, Dr. Nikolai A. Kozyrev of the Soviet Union saw what he believes was an outburst of gas. He thinks it came from a peak in the center of the 75-mile-wide crater. His observations were first greeted with skepticism. Now

they are considered valid by many astronomers.

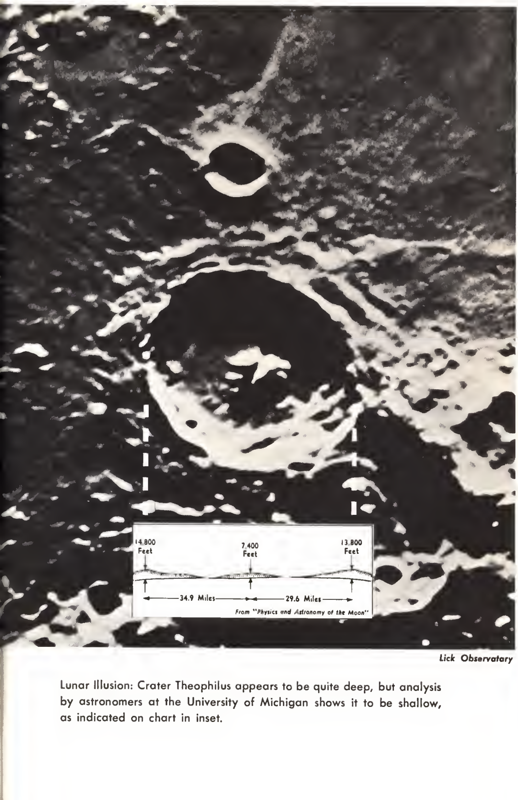
Dr. Kozyrev's interest in Alphonsus was excited by the report of an American astronomer, Dr. Dinsmore Alter, that there seemed to be a mistiness on the floor of this crater. (Dr. Alter's observation was made on October 26, 1956, at the observatory on Mount Wilson, California.) Some earlier astronomers had suggested that there was vegetation in Alphonsus and other craters. They were trying to explain the changes in color that occurred there during the two-week daylight of the lunar "day." One of the best-known of these moon-gazers was Dr. William H. Pickering, an American astronomer who, from 1919 to 1924, observed the moon from beneath the clear skies of Jamaica. He believed the moving patches on the floor of Eratosthenes were swarms of insects feeding on lunar vegetation.

In *Physics and Astronomy of the Moon* Dr. Dollfus proposes that the color changes occur in patches of material with differing reflection properties. As the direction of the sun changes, so do the patterns on the crater floor, much like the beverage advertisements whose images change as one walks past.

Dr. Kozyrev's observations bear on one of the oldest controversies concerning the moon—the origin of its seas and craters. The seas are, of course, dry. The craters are a puzzle for many reasons. Only a small percentage closely resemble volcanic craters on earth. Yet, if they resulted from bombardment by huge meteorites, one would expect many to be elliptical as a result of slanting trajectories. They are almost uniformly round.

Dr. Kozyrev argues in favor of a volcanic origin for most lunar craters. Dr. Eugene M. Shoemaker, of the Astrogeology Branch, United States Geological Survey, attributes most of them to impact. His seems to be the more popular viewpoint.

The Geological Survey is rushing to completion a series of



Lick Observatory

Lunar Illusion: Crater Theophilus appears to be quite deep, but analysis by astronomers at the University of Michigan shows it to be shallow, as indicated on chart in inset.

geological maps of the moon, based on textures of its surface as seen in photographs. The maps will be more detailed as information is gathered from space vehicles. Thus, when the first American steps out of a capsule onto the moon, he should carry in his hand a detailed map of his immediate surroundings. This will include data on the moon's geological formations.

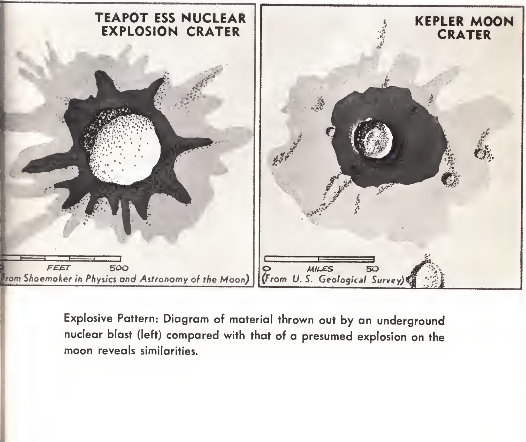
Dr. Shoemaker has identified five such formations, representing five great periods in the evolution of the moon's surface. They are to some extent comparable to the five basic eras of geological time on the earth. Dr. Shoemaker has attempted to estimate the relative ages of these different formations in terms of the extent to which they have been peppered with meteor craters. His method assumes that the rate of meteor impacts has been the same since the solar system was young.

It was over four billion years ago, he suspects, that a massive asteroid hit the moon, producing what appears to be the largest crater, the Mare Imbrium or Sea of Showers. Some estimate the diameter of this asteroid at more than 100 miles. Its explosion not only left a crater more than 700 miles wide, but apparently threw debris over a large proportion of the visible face of the moon. Some of it appears to lie several thousand feet deep. It represents the Imbrian System in the Shoemaker chronology and is predated only by the Pre-Imbrian System. Superimposed on the Imbrian formations are the dark, lava-like deposits that cover such vast areas as the Oceanus Procellarum.

Resting on this Procellarian System is the Eratosthenian and on top of that is the Copernican—each named for one of the largest lunar craters. The Copernican System craters are remarkable for the bright streaks, or "rays," that radiate from them in all directions. They constitute almost irrefutable evidence that those craters, at least, were formed by impact. The distribution pattern of material thrown out from Copernicus is strikingly similar to that from two underground nu-

clear explosions in the United States: the Jangle U and Teapot Ess blasts, both of which left large craters. The rays have always excited curiosity, for they cast no shadows and are, in effect, invisible when the sun is low. One of the first goals of astronauts on the moon will be to collect samples from such a ray. Dr. Shoemaker estimates that the asteroid whose impact produced Copernicus hit the moon some 500,-000,000 years ago.

There are those who believe the moon is older than the earth. Notable, among adherents of this view, is Dr. Harold C. Urey, Nobel Prize laureate now at the University of California in La Jolla. His hypothesis, set forth in the next chapter, seeks, in part, to explain the peculiarly light weight of the moon. One cubic mile of the moon, on the average, weighs only six-tenths as much as a comparable portion of the earth.



Explosive Pattern: Diagram of material thrown out by an underground nuclear blast (left) compared with that of a presumed explosion on the moon reveals similarities.

A novel proposal to explain the low density of the moon has been made by Dr. Thomas Gold of Cornell University. He suggested that it might contain considerable amounts of ice and water at depths greater than a few dozens or hundreds of feet where the temperature is assumed to be uniformly cold.

Even more startling is a report by a leading scientist of the National Aeronautics and Space Administration that, according to an analysis of the moon's motions, it appears to be hollow. The scientist, Dr. Gordon J. F. MacDonald, writing in the July 1962 issue of *Astronautics*, does not suggest that the moon really is hollow. Rather, he believes something is wrong, either with the data or the calculations.

Thus the moon hangs tantilizingly over our heads, inspirer not only of love but of scientific curiosity. From time immemorial it has challenged the genius of the world's leading intellects. Among the earliest records of any sort are those of lunar eclipses (2202 B.C. in Mesopotamia and 1135 B.C. in China). In the fourth century B.C. Aristotle pointed to the curved shadow of the earth in such an eclipse as evidence of our planet's rotundity. In the seventeenth century Galileo noticed one of the most peculiar optical properties of the moon, namely, that although it is spherical, its edges are as bright as its center; and its movements have fascinated such mathematicians as Kepler, Newton and Euler. Today, in anticipation of its exploration at first hand, scientists of Nobel Prize caliber have speculated as to what will be found there. They hope to have the answer in their lifetimes.

DR. HAROLD C. UREY

Earth's Daughter, Sister or Uncle?

Why go to the moon? In the first place, it is our closest neighbor in space. Secondly, the origin and history of the moon have remained a mystery despite intensive study by many eminent scientists during the last century and a half. We may ask, what is the moon? And where did it come from?

Toward the end of the last century, Sir George Darwin, son of the propounder of the theory of evolution, proposed that the moon was torn from the earth by solar tides, and this theory was accepted for many years. The object of the theory was to explain the difference in density of the earth and moon. As nearly as we can judge, the density of the moon, that is, its weight per unit volume, is more nearly like that of the outer parts of the earth than it is of the earth as a whole, the earth having a very large central metallic core. However, it was concluded some thirty years ago that Darwin's theory was not physically feasible, even though it has never been finally proven that such an event did not happen.

But if the moon did not escape from the earth where did it come from?

Is it possible that two bodies like the earth and the moon

could have accumulated near each other in space from debris of some kind, and have markedly different densities? So far as we know there is no reason why the more dense material should accumulate into a large object, the earth, and the less dense material should prefer to accumulate in the small object. Thus, accumulation as an explanation for two planets so near each other appears to us today to be very improbable.

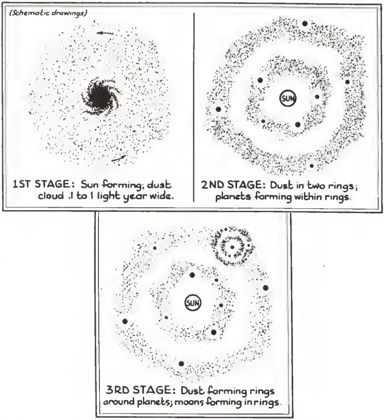
There is a third possibility: namely, that the moon was captured by the earth. This means that the two objects must have moved in very special orbits relative to each other and that sufficient energy was dissipated by tidal friction to cause the two to remain in the neighborhood of each other.

This event would be very improbable if there had been only one moon. It seems likely that if one moon were captured by the earth during the formation of the solar system, there should have been many more such objects present at that time. If this were the case, it would give us insight into the processes of the origin of the earth and planets.

It is most curious that the density of the moon is only slightly greater than what might be expected if it were made from material like that of the sun after the removal of the abundant gaseous material such as hydrogen, helium, water and so forth. We can draw this conclusion today—whereas Sir George Darwin could not—because of the extensive recent studies by astronomers on the composition of the sun.

It is interesting that the moon is more nearly like the sun than are the terrestrial planets. These planets have densities ranging from about 4 grams per cubic centimeter (Mars) to between 5 and 6 grams per cubic centimeter (Mercury), while the density of the moon at ordinary temperatures and low pressures is about 3.4 grams per cubic centimeter. How did this happen?

Perhaps the planets formed at a later stage in the history of the solar system from materials that had been "sorted out" in some way, while the moon is a relict of the earliest stages



1ST STAGE: Sun forming; dust cloud .1 to 1 light year wide.

2ND STAGE: Dust in two rings; planets forming within rings.

3RD STAGE: Dust forming rings around planets; moons forming in rings.

A Theory for the Origin of the Solar System: In 1960 the Swedish astrophysicist, Hannes Alfvén, proposed that the solar system was formed from a dust cloud in the manner illustrated by these three drawings. In the first stage the sun began accumulating from a dust cloud from one-tenth to one light year in width. A light year is the distance traveled by light in one year at 186,000 miles a second. In the second stage the pressure of accumulated dust was sufficient to start thermonuclear reactions in the core of the sun—that is, the sun began "burning." Electromagnetic effects sorted the remaining dust into concentric bands, where it began forming into planets. Finally, in the third stage of Alfvén's model, moons began forming from dust rings around the planets. However, the earth's moon differs from other moons of the solar system in being very much larger in relation to its parent body. The moons of Jupiter, for example, are extremely small in comparison to that planet.

that escaped this sorting process. Thus, the moon may be a very primitive object of some kind, much more primitive than the earth. This sort of argument makes the moon an especially interesting object to study since it may preserve records of the entire history of the solar system.

We turn now to another question. Was the moon ever completely melted? Lord Kelvin in the nineteenth century proposed that the earth formed as a completely melted body. He knew of no other source for the heat of volcanoes except the heat trapped in the earth during its formation. But at the end of the nineteenth century radioactivity was discovered and then it was no longer necessary to assume an originally melted earth. By this time, however, the tradition of an originally melted earth, an originally melted moon and melted planets had worked its way into the astronomical and geological textbooks until, customarily, the expression "when the moon cooled off" was used to introduce many discussions of the moon. But recent studies indicate that there are reasons for believing that possibly neither the earth nor the moon was ever completely melted.

In particular, there are very large differences in elevation on the moon—some six miles' difference in altitude between the mountains and the valleys on the eastern limb of the moon. How do we account for the preservation of such great differences as these? The mountains of the earth are floating on the more dense material below. A similar structure for the mountains of the moon appears most improbable, so that they must be supported by rigid underlying material.

Again, the figure of the moon shows a bulge on the side facing the earth that is difficult to explain, if the interior is molten, unless, as has recently been suggested, there are movements of material (convection currents) within the moon. This bulge is a non-equilibrium one and must be supported by some curious internal characteristic of the moon, such as great strength of the interior or some variation in density in the body of the moon. Neither of these is con-

sistent with a high temperature for the moon's interior.

Such arguments have been advanced in the last ten years mostly by the present writer. Some small degree of acceptance of these ideas by others has been in evidence, even though it is difficult to counter the strong tradition of a century since Lord Kelvin's first work.

If the moon were completely melted at one time, what melted it? How did it cool off, and how did it maintain its irregular shape? These are interesting questions, bearing upon the whole problem of the origin of this supposedly primitive object, and this in turn becomes intimately tied up with all ideas about the origin of the solar system as a whole.

We will soon have instruments flown to the surface of the moon, including a seismometer and devices for analyzing the chemical composition, radioactivity and the mineralogical character of the moon's surface materials.

Other instruments will provide information on the degree of similarity of the moon's surface rocks to those of the earth, which in turn will indicate the nature of the rock-forming processes that occurred on the lunar surface. In addition to these observations, it would be most interesting to determine the age of the moon. This would at once tell us whether or not the moon is a primitive object as has been discussed.

Another advantage of putting man on the moon is that it will be possible to make astronomical observations without the difficulty imposed by the terrestrial atmosphere.

Of course, nature is almost always more complicated than we think it will be, and it surely will require very careful and unprejudiced study to answer some of these questions.

WALTER SULLIVAN

Exploration by Automaton

The world may shortly share in the awesome experience of looking out of the nose of a space rocket as it plunges into the moon at 6,000 miles an hour. This will be possible thanks to six television cameras mounted on each of four Ranger vehicles to be sent to the moon in 1963. At least one should be successful.

A year or so later an unmanned Surveyor vehicle will descend to the lunar surface, slowed by a rocket whose blast will throw up quantities of lunar dust—if in fact the moon is dusty. Once the vehicle comes to rest, the dust will fall back like so much gravel, for on the moon there is no air. Then television eyes, radio-controlled from the earth, will peer down at the moon's surface. They will scan the landscape, near and far, to inform American designers what problems must be overcome when the first manned landing is attempted.

But the Surveyor will do more than scan the scenery. It may reach out a mechanical arm, grasp a specimen of moon material and drop it into a hopper. A miniature automated laboratory will grind the sample, screen it, analyze it and

Photo by George Tames

Unmanned Exploration: Preparing for a Ranger launching at Cape Canaveral with its goal, the moon, in the background.

radio the results to earth. Another Surveyor is expected to carry a drill that can bore several feet into the moon and accomplish another series of automated experiments.

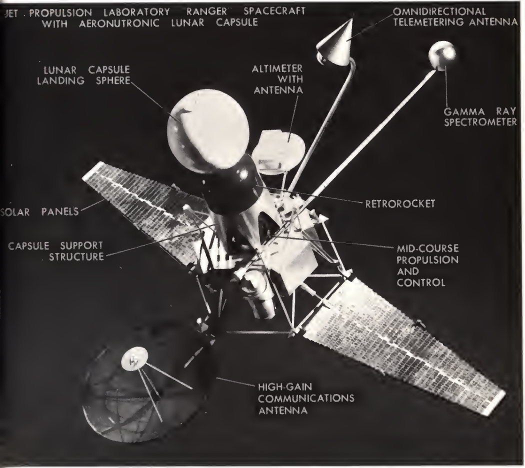
These robots are known as Surveyor Landers. At least seven, it is hoped, will land gently on the moon, starting late in 1964. These landings will carry out amazing feats. Among the tasks proposed is remote-control analysis of the moon surface by X-ray spectroscopy, X-ray diffraction, gas chromatography and mass spectroscopy. The automatons will radio the results to earth.

Special devices will measure the hardness of the surface, its density, compressibility and cohesiveness. Others will test electrical resistivity and acoustical conductivity. The acoustical experiments will be carried out by a telescopic boom that will explode a small grenade some distance from the Lander. Sensors will measure the speed of sound through the lunar crust. Other Landers will carry a three-axis seismometer, a long-term radiation monitor and devices to sense a thin lunar atmosphere or hot gas ejected by the sun.

Soon after the first Surveyor Lander is launched—perhaps by the end of 1964—a series of five Surveyor Orbiters is to be sent to the moon. They will be placed in orbits passing over the moon's north and south poles so that they can send to earth pictures of its surface. These will be used to make improved lunar maps and to select sites for manned landings. It should take one Orbiter a month to collect pictures of the entire moon, as seen from a height of 60 miles. However, the first closeup pictures of the moon's surface are expected from the Ranger shots of 1963. These should reveal the conditions to be expected on the first manned landing. Meanwhile, the lunar landing vehicle is being "overdesigned," with a consequent increase in weight. Thus, the capsule is to be given more strength than it probably will need, including "strong points" on the landing legs. Once surface conditions have been determined, appropriate pads, floats or other de-

vices can be attached to these points.

The Rangers will send pictures every eight-tenths of a second until they hit. They will crash into the moon at a speed



Ford Motor Co.

Ranger model: This spacecraft was designed to rough-land a seismometer on the moon. The instrument, enclosed in the white balsa sphere, is cast loose and brought to a halt near the moon, then allowed to fall onto the lunar surface. This spacecraft will transmit pictures until the capsule is ejected, whereas the later models will transmit images of the moon until the instant before impact.

of 6,000 miles an hour. This means they will transmit their last picture from a height below 8,000 feet. However, details of the surface will probably not become known until the Surveyor Landers arrive safely.

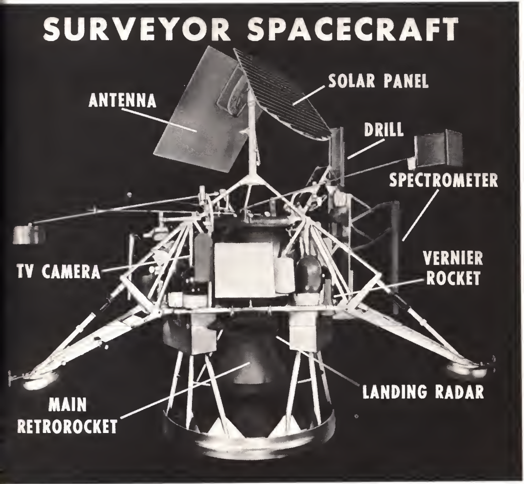
If current proposals are approved, there will be thirty-eight Ranger and Surveyor shots to the moon during the five years of reconnaissance before the first attempt to land men. One shot, Ranger 5, scheduled for October 1962, was not designed to send pictures up to the moment of impact. Like its two unsuccessful predccessors, Rangers 3 and 4, its task was to cast loose an instrument capsule at a height of about 70,000 feet. In the process the camera of Ranger 5 would swing away from the moon. The Ranger 5 capsule, containing a seismometer, was to be halted in space by a retro rocket, then allowed to fall about 1,000 feet onto the moon. The instrument, packaged to withstand this impact, could, it was hoped, throw light on whether there is volcanic activity in the crater Alphonsus. Unfortunately the shot failed.

The first two Rangers were launched in 1961 as test shots. None of the initial five vehicles of this type made a successful flight, either because of its own defects or because of failures in the rockets that propelled them into space. Like the Surveyor, the Ranger is a "bus," or standardized frame onto which a variety of equipment can be loaded for propulsion into space. Such vehicles are launched, if possible, on a regular schedule of a few months apart. If a certain instrument misses one bus, or that vehicle is lost, it can catch a later bus.

The alternative method is to design each vehicle from scratch for the jobs it will be required to do. This, it has been found, makes for unreliability and greater expense.

Because neither Ranger nor Surveyor can make a major course change, the areas of the moon accessible to them are limited. The Ranger cameras point straight down, and hence the vehicle is designed to approach the moon vertically. Its pictures can focus only on a small patch near the center of the

moon's leading, or left-hand, face, as seen from the earth. This area lies in the Oceanus Procellarum, or Ocean of Storms—a vast, seemingly smooth area long thought of as a possible land-



Surveyor: Originol design of the device thot will lond intoct on the moon to somple its surfoce ond scon its londscope. Becouse of difficulties with the Centour rocket, the first Surveyors must be redesigned to cut their instrument lood to 100 pounds from their originol weight of 300 pounds.

Calendar for Unmanned

Date.	Vehicle.
1963	Ranger 6
	Rangers 7-9
1964	Rangers 10-14*
1964 (late) to about 1966	Surveyor Landers 1-7
1964 (end of year) to about 1966	Surveyor Orbiters 1-5
1966	Surveyor Landers 8-12* Surveyor Orbiters 6-8*
1967	Surveyor Landers 13-17* Surveyor Orbiters 9-11*

* Proposed.

Exploration of the Moon

Mission and Payload.
Full-speed impact with six TV cameras. Also on board: ionization chamber to monitor radiation en route.
Same as Ranger 6 except for eleven additional detectors to measure dust, radiation of various energies and magnetism.
Will probably carry TV or facsimile equipment. Still more Ranger shots are being considered in view of delays to Surveyor program.
Retro rocket, accounting for two-thirds of vehicle's weight, will lower it gently. Original design called for five TV cameras plus a series of experiments to sample or drill into the lunar surface, but is being revised to fit payload cut from 300 to 100 pounds.
Will carry two TV cameras to provide stereoscopic mapping pictures from orbit at 60-mile elevation. Various detectors will be aimed at areas being scanned. After main mission, orbits will be studied to learn moon's shape and internal structure. Radio transponders on board for precision tracking.
Improved boosters may permit payload increase to 300 pounds.
Missions undecided.

ing site for astronauts. However, it is probably scarce in points of scientific interest. The location of the first manned landing, according to a leader of the project, will be chosen "for its apparent scientific potential." Landing sites must be chosen early so that the available Surveyor Landers can be used for detailed reconnaissance. It is planned to send one Lander to each site before the arrival of a manned vehicle.

The Landers will be able to descend at angles up to 45 degrees from the vertical. This opens to their exploration almost all the eastern half of the visible lunar surface, plus a small part of the western half.

The motion of the moon around the earth is eastward. While it rises in the east and sets in the west, this apparent westward motion is due to the earth's rotation, whose effect is far greater than the moon's true movement. The geometry of the flight plan for landing two men from a lunar orbit and getting them back into the same orbit requires that their capsule be brought down within 10 degrees of the moon's equator.

The Surveyor program has been hampered by a major delay affecting the Centaur rocket. This vehicle, the first to use liquid hydrogen, the ideal fuel for maximum thrust, is running about a year and a half behind schedule, and, because of uncertainty as to the Centaur's lifting power, a cut in the Surveyor payload from 300 to 100 pounds has been necessary.

Nevertheless, the Landers will carry at least two television cameras for scanning the landscape, plus one aimed down to reveal the surface texture. The field of view for the two landscape scanners will be determined by mirrors controlled from the earth. They may be used in tandem for stereoscopic pictures.

It is similarly hoped that the two cameras envisaged for the Orbiter can be used together, stereoscopically, to measure the heights of surface features. Some two-score scientific experiments have been suggested for the Orbiters. In many of them

the recording instruments would be aligned to scan the same lunar scenery as that being viewed by the television cameras. Thus, any emissions, such as gamma rays, neutrons or infrared light from the surface, could be related to the feature (a volcano, for example) from which they came.

Once the Orbiters have done their picture-sending they will be used for an indefinite period to study the moon's shape and internal composition. A body's orbital path is determined by its own momentum and the gravitational attraction of the body it orbits. A lopsided shape of the parent body, or lumpiness in its interior, makes for an irregular orbit. Revolutionary discoveries have already been made about the earth using satellites (for example: the shape of the Northern Hemisphere is not identical to that of the Southern Hemisphere).

The lunar Orbiters will be equipped with radio transponders that will speak only when spoken to. These transponders will make possible highly precise calculations of the flight path through determinations of range and relative motion of the vehicle. The results may help resolve whether the moon is a sister planet to the earth or has an internal structure pointing to a different origin.

A further, long-range role of the Orbiters will be to serve as relay satellites, much like Telstar. When expeditions venture to the far side of the moon, or instruments are landed there as monitors, they will require some means whereby they can communicate with the earth. It is hoped that Orbiters can do the job.

WALTER SULLIVAN

Tasks for the First Explorers

No one has ever held in his hand a chunk of material known to have come from another large body of the solar system. Our knowledge of the composition of the celestial bodies has, in effect, been educated guesswork. So, whatever else they do, the first two men to reach the moon will be asked to bring home a few pieces of it. Because of the dangers of their venture they will be required to do little in the way of experimentation.

Scientists in the National Aeronautics and Space Administration propose that the first astronauts carry out simple tests of soil strength to aid in planning future operations. Otherwise, their chief scientific task will be to look around. It has also been proposed that they bring back a sealed sample of lunar "soil" to be cultured for signs of dormant life.

Despite limitations on the work that can be assigned the initial moon visitors, the arrival of Americans there will mark the first occasion when this country's man-in-space program pays off major scientific dividends. Some skeptics have argued that there is nothing an astronaut can do that an instrument could not do better. Those planning for Project Apollo

believe they have the answer. An instrument designed for a specific task, they concede, can usually do it more reliably than a man. But, they add, "on the moon we don't know what an instrument will have to do." A man, particularly one who is sophisticated scientifically, can respond appropriately to the unexpected. Much of what is encountered on the moon—and, later, on the planets—will be unexpected.

One of the primary tasks of the lunar astronauts will be to set up scientific instruments that can collect and broadcast data long after they leave. The installations will be powered either by sunlight or by nuclear batteries, with directional antennas aimed at the earth. The knowledge of these men will be irreplaceable in selecting the optimum spot, say, for a seismograph.

Another job of the astronauts will be to look for subtle signs of erosion. The moon has no air and, hence, no weather. However, because of the absence of air, its sunny side is constantly exposed to the "solar wind." The existence of such a "wind" has become widely accepted in recent years. It is a steady outrushing of hot gas, or plasma, from the sun. The plasma is extremely thin, but over millions and billions of years it must have some erosive effect on the lunar surface. What is it? By digging into the moon it may be possible to discover past changes in the intensity of this "wind." And could there be another kind of erosion, produced by the electrical activation of dust? There is no equipment in sight today that can replace a man in seeking answers to such problems.

Hence the lunar and planetary sciences group, in NASA, has been asked to propose a list of jobs to be done by the first ten parties of men to land on the moon. The list is most tentative. The initial sojourns, on the moon, will last only a few hours, or at most, two days, but, by the ninth and tenth landings, it should be possible for the visitors to remain up to six days.

Mobility will be essential for some of the planned explora-

tion. A recent decision to design a Lunar Logistic Auxiliary to be landed before the explorers, laden with extra oxygen, food and equipment, may provide a solution. It is possible that these 50-ton devices will carry vehicles that will make the astronauts mobile. The Apollo planners do not believe that man will ever be able to hike alone across the moon, because his need for oxygen, shelter and other support will be too great and there is always danger of a solar eruption that would drive him to shelter.

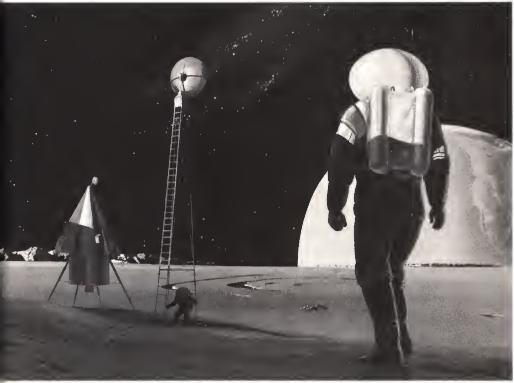
The Astrogeology Branch of the United States Geological Survey has already picked fifteen sites on the moon that merit priority investigation. Another ten sites have been picked by NASA scientists. There is some overlap. High on both lists is Alphonsus, a crater in which volcanic activity has been reported. Once moon-orbiting satellites have provided data for detailed lunar maps, suitable landing sites will be looked for near such spots and additional ones selected.

As early as the second manned landing, attempts may be made to detect the tenuous atmosphere that may exist on the moon. This has high priority because landing of space vehicles will unavoidably introduce the "foreign" gases the rockets use to slow descent for a soft landing. Some scientists believe there is a very thin atmosphere of atomic hydrogen enveloping the moon—a by-product of the solar "wind." Sunlight should make it glow with an ultraviolet light, known as Lyman alpha. Hence, on the second lunar landing, it is proposed that an astronaut scan the horizon with a Lyman alpha detector.

Another instrument, tentatively slated for the second manned landing, is a spectroscope. This will analyze surface features too delicate to bring home. These would include such phenomena as metallic "whiskers" and structures caused by solar "wind" erosion.

A radio telescope may be carried to the moon on the first of two landings scheduled to place the astronauts as close as

possible to the center of the lunar disk, as seen from the earth. The telescope antenna would consist of two wires laid out in a line a mile or so in length. They could, perhaps, be shot out by a device comparable to the line-throwing gun used in harpooning whales. An antenna of this type could pick up very-low-frequency radio emissions from various parts of the sky. Such emissions cannot be detected on earth because they are



North American Aviation

Moonwork: With the earth as a giant orb over the horizon and the sun-baked surface at 250° (F) in airless environment, two astronauts go about their explorations. They wear reflecting suits that contain temperature-controlling units and an oxygen apparatus. Here they set up an antenna such as might be used to transmit data to earth from instruments left behind when the visitors return home.

unable to pierce the atmosphere.

One of the proposed tasks for early visitors to the moon is to use a surveyor's theodolite to determine the precise extent of the moon's seeming wobble, or "libration." The chief reason for this wobble is that the speed of the moon's spin is constant, whereas the speed of its elliptical flight around the earth is not, and the difference in speeds means that the same point on the moon does not always point towards the earth. As a consequence, we can sometimes look almost eight degrees around the edges of the moon and thus have been able to map somewhat more than half its surface. Another form of libration enables us to see more of the moon's polar regions than we otherwise could because the axis of the moon's spin is not quite perpendicular to its path around the earth.

One of the most ambitious schemes slated for explorers of the moon is to drill a hole several feet into solid rock. This would be used to measure the heat flow outward from the core of the moon, narrowing the divergent theories on the structure of the body. Some scientists say the moon's core is molten, others that it is not. Still others believe the moon is a conglomerate of meteorites of metallic and stony composition, like a gigantic loaf of raisin bread. The first travelers across the moon should carry a magnetic device to see if such lumpiness exists.

Scientists analyzing specimens brought back from the moon will ascertain if they contain hydrated substances from which water could be obtained to supply a lunar base. Other scientists will make age determinations of the various lunar formations through analysis of radioactive decay.

Once such formations have been dated, it may be possible to find clues within them to past changes in the solar system. These, in turn, would help solve some of the riddles in the history of the earth, its origin, its climate and the evolution of its life.

HAROLD M. SCHMECK, JR.

Space Infection

One of the strangest and most important problems the space age faces is that of world-to-world contamination.

No man in history has stepped out on a land that is totally sterile, lacking germ or plant or insect or any other living thing. The idea is almost unthinkable to minds conditioned by the teeming planet Earth.

Biologists fear that space vehicles landing or impacting on other celestial bodies, will contaminate them with earthly organisms. Conceivably, such microbes might seriously distort the pattern of native life or even seed new life derived from earth-born species. Such contamination would be a scientific catastrophe, biologists believe, damaging and perhaps destroying evidence of immense value to the understanding of life's origins here and elsewhere.

Even on the seemingly sterile moon there is at least a possibility of finding dormant or deceased forms of life. This would be true, in particular, if the concept of panspermia should prove valid. In this view, spores of primitive organisms escape from the planets on which they evolved and drift through space, seeding life whenever they land on a planet with a suitable environment.

Although this idea has only a few scientific adherents, there is great interest, on the part of biologists, in the extent to which complex molecules, such as those necessary for the evolution of life, might exist on a body like the moon. Once men arrive on the moon, of course, the danger of contamination will increase. It is for this reason that one of the astronauts' first jobs will be to collect samples for biological analysis.

Dr. Joshua Lederberg, the geneticist and Nobel Prize winner, has pointed out that if microbes from earth found conditions congenial on another planet they could conceivably sweep across that entire world in days or weeks. Whatever native record of life or proto-life that planet contained would be obscured, perhaps destroyed.

On earth all life is based on certain essential elements such as carbon and hydrogen and on certain chemical arrangements and combinations. Theories have been advanced to show how these compounds must have accumulated in earth's early environment and how living forms emerged. It would be of huge value to biology to see whether or not the same processes, or some of them, have taken place on other bodies of the solar system, and whether or not life, if it exists elsewhere, is based on the same chemicals and compounds.

The first American attempt at a moon probe in 1958 was thoroughly decontaminated by use of cartridges that injected a lethal emulsified liquid into the sealed compartment within the rocket's nose cone which contained the moon vehicle itself. Later American moon-probe attempts were reportedly sterilized in the same way or by ultraviolet light. The Soviet package that hit the moon in 1959 was also thoroughly sterilized, according to reports from Moscow. The problem becomes more difficult, of course, as the size of the space probes and their payloads become bigger and more complex. And the problem becomes greatly complicated when man first sets foot on another world.

But there is still another aspect to consider. Writing in the *Bulletin of the Atomic Scientists,* Dr. Lederberg and a colleague, Aaron Novick, observe that interplanetary contamination is not necessarily a one-way street. "By the next decade, vehicles may be making round trips to the planets, and we must reckon with the bizarre possibility that the returning vehicles may infect earth with life from some other planet," they wrote.

Contamination: Efforts will be made on lunar flights to prevent contamination of the moon by earthly microorganisms. Shown here are technicians of the Ford Motor Company's Aeronutronic Division standing outside an airtight, safety-glass box, working on the assembly of Ranger 3 capsule components with special shoulder-length rubber gloves.

Since no one knows what life, if any, exists elsewhere in the universe, the importance, or lack of importance, of such an occurrence cannot even be guessed, they said. They advised taking steps, however, to insure that man knows what to expect from such an event before the first round trip to another world has been accomplished.

DAVID BINDER

Social Impact

For a thousand miles along the southern crescent of the United States, from Florida's palmetto thickets to the Texas ranchlands below Houston, the nation's space industry has become a catalyst. With huge launching pads and rocket vehicle factories, with battalions of scientist-technicians and regiments of construction workers, the space program is causing profound changes on this part of the earth.

The focal points for the Federal space effort, and particularly Project Apollo, are Cape Canaveral, New Orleans and Houston. But the space industry is also altering the economic structure of broad areas on the Florida mainland and in southern Mississippi. All along the crescent it is changing the patterns of living and labor.

"This is foreverland," said a lieutenant colonel at Patrick Air Force Base on Cocoa Beach, just south of the Canaveral launching complexes. "It may be hard to accept, but this loud beach is going to be a piece of Americana for the next five hundred years."

In some areas, like the Florida counties around the cape, the impact will be sharp on housing, schools, hospitals and

roads. The reasons include the peculiar geography of the coast, with its small, independent cities strung along the shores for 70 miles. Already, rocket activity at Canaveral has made the eight-mile, two-lane causeway from Cocoa, on the mainland, to Cocoa Beach a miniature version of the Long Island Expressway. Commuters complain of fifty-minute drives to their nearby homes.

In the New Orleans area the space impact will be partly absorbed by the Louisiana metropolis and partly by the vast timber and bayou hinterlands across the state line in Mississippi. These are the places where the Advanced Saturn launching vehicles will be manufactured and tested.

In southeastern Texas the space industry is piling on top of a half dozen booms that have already made Houston the sixth largest city in the country—cotton and cattle, timber and oil, shipping and petro-chemical plants. But the space industry will be more an accelerator than a prime mover in the Houston economy—at least for the time being. Texas boosters are quick to point out, however, that the location of the Manned Spacecraft Center 20 miles south of downtown Houston is sure to be a magnet for the next generation of space industries.

Officials of the National Aeronautics and Space Administration try hard to play down the boom talk along the southern crescent. Their policy is caution. They make population forecasts and community development studies with care and precision in an attempt to dampen enthusiasm with hard facts, but nothing the space agency says or does can halt communities like Titusville, Florida, or Picayune, Mississippi, or Houston from laying claim to titles like "Missile City," "Gateway to the NASA Test Site" and "Spaceport, U.S.A."

Nor can the agency deny that it expects to spend more in a year—one budget forecast is $2,000,000,000 a year for the next twenty years—than the entire Federal investment in the

Photo by David Binder

Present: This home, in a setting of trees draped in Spanish moss, near Gainesville, Mississippi, must make way for the space age. Rockets for the moon project will be tested here.

Tennessee Valley Authority. The total expenditure on T.V.A. was $1,200,000,000.

To be sure, a large portion of the space budget will be spent at West Coast and Middle West rocket plants and on electronics hardware made in Minnesota, Massachusetts, New York and Maine. But the major share to be spent on new space installations will be in the southern crescent.

This, in turn, has engaged the Government space people in a wide range of physical and social endeavors, including the new four-mile canal for the Intracoastal Waterway above the Cape, a private-access causeway to the moon launching areas on the Florida coast, and participation in a Federal wildlife conservation project to guard sixty varieties of ducks that live on Merritt Island, just inland from the moon launching pads.

In Mississippi, the space people, aided by the Army Corps of Engineers, are engaged in moving 2,695 residents out of a 142,000-acre area that will be the static testing site for Advanced Saturn rockets. Another 25,000 acres is being evacuated in neighboring Louisiana.

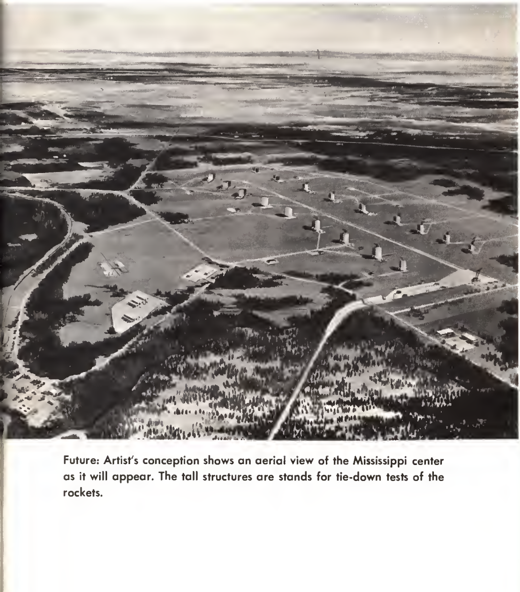
Plans are being drawn to straighten some sharp bends in the placid Pearl River that runs through the site and will be used to barge the heavy rockets to the firing line.

Some of the impact is easy to gauge in terms of dollars, acreage and population. Some is not. For example, the Canaveral projects are using large amounts of construction sand from Ocala, Florida, 100 miles away, and steel from Alabama mills, more than 200 miles distant. Demand is growing and suppliers are benefiting accordingly.

More than 50 per cent of the employees working on space projects in the New Orleans area are local residents. And the space agency has announced a policy of ordering as much equipment as possible from manufacturers in the immediate area. The same goes for Houston. Thus, the dollars spent and the dollars generated—for haircuts, medical attention and

groceries—are affecting large areas around the space program sites.

By the same token, some of the human dislocations are relatively simple to measure. Others are sociological problems that defy precise analysis. The space agency has a good idea of how many people it is moving in and out of the Cape, New Orleans and Houston areas, but it is not at all sure what is going to happen to the new arrivals or the old residents.



Future: Artist's conception shows an aerial view of the Mississippi center as it will appear. The tall structures are stands for tie-down tests of the rockets.

Along the Florida coast, for instance, the space developments have given impetus to the demands of Brevard County's 10,000 Negroes for equal rights in housing, employment and schools. Resistance to these demands is also mounting. Both Florida whites and Florida Negroes predict violence. Add to this population thousands of engineers and technicians—a large number coming from the North—and what happens? Or, take the serene Mississippi and Louisiana communities of Hancock County and St. Tammany Parish, draped in Spanish moss and aglow with brilliant crape myrtle —crimson, purple and pink. What happens to the people in these towns around the new test site or to the evacuees who have spent their lives in antebellum homes along the Pearl River? What is in store for those dwellers in the slash pine forests to the west who divided their carefree days between angling for green trout and tending cornmash stills, locally reputed to be among "the finest in the country"? Or what happens to the little theater in Bay St. Louis, the recreation program in Picayune and the school system in Slidell when the space operations people begin settling in the next few months? Will the program quicken the stately quadrille of business activity in New Orleans? Will it change Rice and Houston Universities in Texas?

Space agency authorities are deeply concerned with most of these questions. And they have answers to a few of them. So do a number of communities that have prepared for the bold changes in the impact areas. As to the over-all effects on communities and regions in the southern crescent, there are already guidelines to be found at Cape Canaveral and Huntsville, Alabama, where the space business has been expanding for the last decade.

Here is a close-up of the southern crescent:

Cape Canaveral

To a first-time visitor the Cape presents a visual shock with

its billboards and gaudy motel façades accentuated in the Southern sunlight. There is a gold-rush air of hard work and hard play in the saloons and honky-tonks that line the beach strip. And despite the engineers and scientists who live here, the hard-hat society of the construction workers seems to prevail.

A European industrial designer who makes frequent trips to the Cape recently termed it a "cultural desert." He added that the highly trained and educated newcomers had arrived with "little or no cultural baggage." The designer, Jaap Penraat of the Netherlands, concluded: "It is as though we were launching a man to the moon from a billion-dollar junk heap."

Yet in Cocoa Beach, the Surfside Players claim sell-out audiences for their amateur theatrical productions. The local library has a booming circulation, and an amateur artists' group is also active. Strangely enough, however, the dramatic rocket launches have drawn few poets and novelists to sing the songs of space.

The Cape atmosphere is a combination of teamwork and transience. "There is a sense of identity here," said a Cocoa Beach physician who arrived several years ago. "Everyone feels they are part of the space team—I love it." Yet the turnover of team members is high. Contract crews move in and out.

One keynote is youth. In Brevard County, the heart of the Cape impact area, the median age is twenty-six years. A longtime resident remarked that Ponce de León had passed by Canaveral in 1513 during his search for the fountain of youth and added, "He was 450 years too early."

In the decade from 1950 to 1960, Brevard, home of the Air Force Missile Test Center, grew in population from 23,000 to 111,000. The 1962 population was over 140,000. Part of this increase could be attributed to the general growth of Florida's coastal counties, which added about 35 per cent to their population in the same decade. But Brevard's growth was more

than 200 per cent. This was due mainly to the influx of more than 20,000 space program employees who worked at the 17,000-acre Air Force launching area on the Cape. Now the space agency is enlarging the launching area by 88,000 acres above and inland from the Cape for the man-on-the-moon shots.

According to estimates by the Air Force Operations Analysis Office, the new facilities will raise the launching-site work force from 24,451 in 1962 to 38,162 permanent employees in 1967. Counting family members, this will add more than 50,000 to the area's population. During the same period the Cape payroll will rise from $150,000,000 to $200,000,000. The initial space impact severely strained Brevard County's community facilities, but thanks to generous injections of Federal and state aid, it has largely been absorbed.

It would seem that the Cape area is better prepared for the Apollo impact. In 1961 Brevard joined with five adjoining counties—Indian River, Volusia, Orange, Osceola and Seminole—to form the Joint Community Impact Coordinating Committee. It was hoped there would ultimately be a regional planning council.

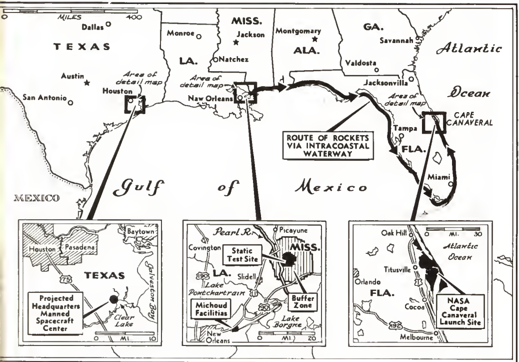
The impact has manifested itself in hundreds of places, not the least in real estate values. Beach property was going at $20 a front foot at the end of World War II. Now some owners are asking $1,000 a front foot, or more, in Cocoa Beach.

New Orleans

In Washington and in other parts of the country, legislators have asked why the space administration is concentrating its prime operations along the southern crescent. The most obvious reply is that ice-free water transportation routes were available there—a must for barging heavy rocket hardware. But anyone who has had a chance to view the enormous Michoud Plant in New Orleans, where Saturn first-stage boosters are to be built, or the future test site across the state

line in Mississippi, gains dramatic proof of the fortuitous nature of these locales.

The first windfall was the Michoud Plant, an Army Ordnance factory that has nearly 2,000,000 square feet of manufacturing space. Until now it has been a white elephant. Located 15 miles northeast of downtown New Orleans, the



Southern Crescent: Project Apollo is leading to a sudden industrial expansion in three areas from Florida to Texas. Rockets will be built and tested near New Orleans and launched near Cape Canaveral. Astronauts will be trained near Houston. The space program has made many changes in the areas' patterns of living and labor.

844-acre site has its own airstrip, access to a barge canal, broad parking areas, a nearby power plant—just about everything the space agency could desire.

The plant is tooling up for construction of the Saturn boosters under a contract with the Chrysler Corporation. Soon the Boeing Company will take up work on Advanced Saturn stages in the western half of the plant. Employment at Michoud in mid-1962 was about 1,200, with an annual payroll of $14,000,000. Peak employment, in the summer of 1963, is expected to be 7,000, with a payroll of $69,000,000, and space agency officials are reckoning on a $175,000,000 expenditure on Apollo hardware at Michoud.

Thirty-five miles northeast across Lake Ponchartrain and the five estuary branches of the Pearl River is the space agency test site. Centered in Hancock County, it will take in small corners of Pearl River County to the north and St. Tammany Parish in Louisiana to the west.

Here was another windfall, a sparsely settled area easily reachable from Michoud by water, rail and road. On the edge, in Slidell, Louisiana, was another white elephant, a two-million-dollar, brand-new Federal Aviation Agency computer center being abandoned in favor of a Houston facility. The space agency gratefully took it over.

One result was displacement of the 195 families in the center of the test site area. Their property was paid for following elaborate appraisals by the Army Corps of engineers. The majority have moved to Picayune, a handsome industrial town of 10,000 on the northern rim of the site. They have accepted the change, but few of the citizens of on-site towns like Gainesville are pleased with their prospects.

The Mississippi Test Site will cost about $93,000,000. It will require a peak of 6,000 construction workers in 1964, and between 1,500 and 2,000 technicians and engineers will be needed to operate it. Some construction personnel will be

drawn from nearby towns, and the bulk of the operations people are expected to settle in the neighboring towns of Bay St. Louis and Pass Christian on the Gulf Coast and Picayune and Slidell farther inland. These cities appear well prepared for the impact. New schools and hospitals are already established in Bay St. Louis, Picayune and Slidell. Reasonably-priced housing developments are going up.

The only sour note seems to have been struck by the Mississippi state government. In Hancock County, community leaders told a visitor that the officials in Jackson had not lifted a finger to help them prepare for the space impact or to aid in resettling the test site families. Instead, the Mississippi leaders have busied themselves trying to lure private industries to locate in the southern part of the state.

Over in New Orleans, the space program has drawn an enthusiastic response from city officials, particularly Mayor Victor H. Schiro. Shortly after the site selection, Mr. Schiro appointed a special co-ordinating committee to deal with impact problems. The committee, which has more than a hundred members, including three Negro community leaders, is working closely with the space agency. A New Orleans member of the National Association for the Advancement of Colored People told a visitor that Negroes were satisfied with their share in the program so far.

A visitor leaves the New Orleans-Mississippi area with the feeling that both the urban and rural areas will absorb the space impact without sacrificing either their charm or their culture.

Houston

Ever since Houston was picked as the site of the Manned Spacecraft Center in September 1961 there has been talk of pork barrel tactics in Washington and other quarters.

Critics pointed accusing fingers at Vice President Lyndon

Johnson, a loyal Texan who is also chairman of the National Aeronautics and Space Council, and at Texas Representative Albert Thomas, Democrat of Houston, who is chairman of the House Subcommittee on Independent Offices Appropriations, which deals with the nation's space expenditures.

Yet an official who was a member of the site selection said that Houston ran a close second following a location in California for the proposed Spacecraft Center. The selection team also agreed that Houston's water-route proximity to New Orleans and Canaveral made it particularly desirable. Another prime requisite filled by the Texas locale was the presence of two universities, Houston and Rice. Both institutions have been asked to provide graduate training facilities and to make available technical publications for engineers and scientists at the Spacecraft Center.

Houston's share of the pie-in-the-sky is also supposed to include the $30,000,000 Mission Control Center for the lunar landing program. Both facilities will be on a 1,600-acre site next to Clear Lake, which has a channel opening into Galveston Bay on the Gulf Coast. Eventually this area will be annexed by Houston, according to local officials.

In 1962, 575 construction workers were engaged on the project, most of them from the Houston area. The work force is expected to increase to 2,500 within a year as the second and third phases of construction are undertaken. The total budget: about $123,000,000.

Thus, the major portion of Houston's official space industry will be concentrated in a relatively small area and will employ a relatively small number of workers.

But Houston is counting on a large space impact from private industry. Robert Brewer of the Chamber of Commerce said that five electronics concerns plan to build factories.

The space industry has also catalyzed Houston's real estate market. Land prices near Clear Lake have risen from $3,000 an acre to more than $50,000 an acre, according to Mr. Brewer.

Thus, in a manner reminiscent of wartime, a national effort is stimulating industrial growth and social change, both in areas already prospering and in those that have long been on the sidelines.

DAVID BINDER

Soviet Enigma

When the Soviet Union, a country renowned for its expert weight-lifters, heaved two manned spacecraft into tandem orbits on August 11 and 12, 1962, the world was awestruck.

The initial impression of many scientific observers and most laymen was that the Russians had taken a long step forward in the race to the moon. To some it appeared that the United States was already hopelessly outdistanced in that competition, for the Soviet achievement included not only the feat of launching two space vehicles within a period of twenty-four hours but also what one American scientist called "real pickle-barrel shooting." This was a reference to the precision timing and guidance control that permitted Vostok III and Vostok IV to approach within a few miles of each other while hurtling around the earth at 18,000 miles an hour.

Major Nikolayev, the pilot of Vostok III, reported later that for a time he could see the Vostok IV craft carrying his "celestial twin," Colonel Popovich. Thus the Russians appeared to have come tantalizingly close to physical rendezvous in space, a feat absolutely essential to manned lunar

flights and later interplanetary flights. The United States, for its part, does not expect to achieve a rendezvous of space ships until late 1963 or early 1964, when this will be attempted with a two-man Gemini craft and an unmanned satellite. Short of rendezvous, the Soviet Union again demonstrated the reliability of its heavy launch vehicles—apparently the same 800,000-pound-thrust rockets that carried Gherman Titov and Yuri Gagarin into orbit in 1961. In fact, some American observers were surprised that the Russians did not show off larger, more powerful rockets in the third and fourth Vostok flights. Even so, the Vostok rockets developed thrust power more than two times as great as the Mercury program vehicles that carried Colonel Glenn and Commander Carpenter into orbit. (On one occasion Major Titov said his rocket had a thrust of 1,300,000 pounds, but other Soviet information indicates it was 800,000 pounds and this is the figure generally accepted in the United States.)

According to present estimates by officials of the National Aeronautics and Space Administration, United States vehicles with power comparable to the Vostok rockets will not be available until 1965, when the Saturn C-1 becomes operational for manned flight. In the meantime, the lift-off weights of spacecraft of the two countries are expected to remain in stark disproportion—10,430 pounds for a Vostok against 4,200 pounds for a Mercury capsule.

Since weight-lifting ability is the prime requisite for space travel, it is clear that the Russians presently have a commanding lead in the big race. From here on, however, even the most dispassionate judge of the competition finds himself in a realm of speculation as mysterious as outer space itself. To reach the moon, more than 220,000 miles away, and return in a manned capsule will require a rocket with a thrust of over 7,000,000 pounds, a rocket 350 feet high and bigger in diameter than an ordinary house, a rocket with electronic components many times more reliable than pres-

ent equipment. Neither the Soviet Union nor the United States is believed capable of building such enormous vehicles now, and it is thought by many competent American observers that the two nations are roughly equidistant from that accomplishment. Their reasoning is based on seemingly extraneous considerations such as investment resources, industrial capacity and cold war commitments, in addition to technical know-how. Regardless of the detail and accuracy of such estimates, however, they remain largely speculative, mainly because we know so little about the Soviet space program and because much of what we do know cannot be verified, whether it concerns successes or failures. For that matter, much of what is known by United States officials about the Russian program is kept quiet for security reasons. Finally, it may be safely assumed that some estimates on relative strength in the next phase of the space race are made for political reasons or as special pleading on the part of military leaders intent on budget increases. All this puts the interested private observer in the undesirable position of having to rely primarily on Soviet information, which cannot be verified, about Soviet flights. The watchword, then, is caution—caution in gauging the Russian space effort and caution in comparing it to the American program. Past performance is the only realistic measuring stick, and even here the observer is hard put to it to obtain reliable information.

On August 17, 1962, two days after Major Nikolayev and Colonel Popovich completed their three- and four-day orbiting missions, *Pravda* carried an article by Leonid Ivanovich Sedov, chairman of the Commission for Promotion of Interplanetary Flights of the Soviet Academy of Sciences since 1958. Reviewing the Vostok expedition, the academician wrote: "The prime deduction to be drawn from the past stages of Soviet research is the reasonableness, the economy, the purposefulness of a program that is at once classical, bold, simple and natural. Each new experiment was a logical

development of preceding experiments and was a major step, which, once taken, was regarded as the only correct one and the best step in the sequence." This statement has a dialectical ring to it that would have made Lenin proud, but it is also an extremely cogent and succinct description of the Soviet space effort.

From the reported launching of the first Sputnik on October 4, 1957, to the latest Vostok flights, the Soviet program has been characterized by large and often dramatic strides—the orbiting of the dog, Laika, in November 1957; the Lunik series of 1959, which permitted a hard landing on the lunar surface by one space vehicle and photographing the far side of the moon by means of a television camera by another; the orbiting and recovery of the 4.6-ton Sputnik V capsule containing two dogs, biological specimens and a variety of scientific instruments; and, finally, the Vostok manned flight series commencing with Gagarin's one-orbit flight on April 12, 1961. At the time of this writing the Soviet Union has launched a total of twenty-six successful space vehicles on purportedly peaceful missions—far less than the number of United States launches, but qualitatively a good deal more advanced. The list of publicly known Soviet launch failures is very small.

Similarly, little is publicly known about the successes and failures of the Soviet military space program. Yet it was a desperate military need that put the Soviet Union in the space business to begin with—the need to deliver heavy nuclear paylcads to far-off enemy targets. Knowing that the United States had a good lead in the development of strategic bomber forces and that the early nuclear bombs were "crude" and extraordinarily heavy, the Russians began to design and build relatively large rocket carriers in the late nineteen-forties. Drawing in part on German rocket experience in World War II and also on the genius of their own rocket engineers, they methodically developed booster en-

gines of increasing reliability and performance into the nineteen-fifties. These were and are the rockets that have been the mainstay of the Soviet intercontinental ballistic missile arsenal. Beyond the ICBM phase of the Soviet military program, however, the observer again enters the realm of speculation. Since the Vostok flights, several Western scientists have surmised that the Russians now have the capacity (1) to orbit military satellite platforms and (2) to knock down United States "spy" satellites. It was perhaps this military potential in terms of guidance and control as well as weight-lifting that prompted Marshal Rodion Y. Malinovsky, the Soviet Defense Minister, to make this comment on the Nikolayev-Popovich flights: "Let our enemies know what technology and what men our Soviet power has at its disposal."

High on the Russian list of priorities and equally high on their list of achievements have been booster engine reliability, precision control in launching and the study of human capabilities in the space environment. Though earlier booster successes were significant, the most striking demonstration of reliability came when the Russians fired Vostok III and Vostok IV from adjoining pads on an exact schedule designed to bring the two ships close to each other in orbit. This was probably done with few holds on the countdowns. American scientists later marveled at the Russian feats of high-speed computation and error-correcting and programming that permitted Vostok IV to achieve an orbit nearly identical to that of Vostok III. As for control through electronic devices, the Soviet Union has shown again and again that it has high capability—whether in the first three Sputniks, which attained initial low-point altitudes of 142, 140 and 135 miles, or in the Lunik III shot on October 4, 1959. Commenting on this project, F. J. Krieger of the United States Air Force's RAND Corporation, on the West Coast, has written: "The success of the Lunik III experiment was

due largely to the system of orientation and stabilization incorporated in the vehicle. The system consisted of solar and lunar sensors, gyroscopic stabilizers, electronic logic devices and four pairs of gas jets to control spin around any axis. On October 7, when the automatic interplanetary station rounded the moon at a distance of 63,000 kilometers and approached the line joining the sun and the moon, it was stabilized and aligned for photography. For forty minutes the lenses of the camera were trained on the moon."

Soviet electronic equipment has in the past been called relatively unsophisticated and often ponderous, but there is evidence that it has been adequate for most military and space program tasks for which it was primarily designed. Even so, the Russians have had their electronic equipment failures, just as the United States has. One was Sputnik IV on May 15, 1960, which failed to de-orbit as planned. Another was Sputnik VI on December 1 of the same year. Then, on February 12, 1961, they launched the Sputnik VIII, which was to send a half-ton satellite toward the planet Venus from an orbiting space platform. The first part of the mission succeeded, but radio contact with the planet-bound satellite was lost fifteen days later. According to information gathered by United States agencies, five other Soviet deep space probes failed in the period from October 1960 to September 1962, including two abortive Venus shots on August 25 and September 1, 1962, and two probes aimed at Mars in 1960.

Among the greatest advances in space potential have been the Russian attainments in the study of man's behavior and requirements in the celestial environment. The bioastronautic experiments began with animal-bearing vertical rocket firings in the early nineteen-fifties. Now, with the Nikolayev-Popovich flights, they have produced invaluable information about the effects of weightlessness on man for periods of three and four days. Since a round-trip lunar journey is ex-

pected to take seven to ten days, such findings are essential. In addition, the Russians have learned a great deal about man's food and sleep requirements in space.

Finally, despite industrial plant limitations and a general shortage of investment resources, Russian engineers have apparently been able to design and produce rocket equipment with economy and reliability—"the Soviet way," as one of the cosmonauts said, "sound and well." Perhaps the methodical developments in the Soviet space program can be credited to the highly centralized administration possible in an authoritarian society. Whatever the reasons, no one has ever accused the Russians of "overdesign" in rockets, a charge frequently leveled at American engineers. Nor has anyone ever accused the Russians of having a helter-skelter space program with competing designs and techniques.

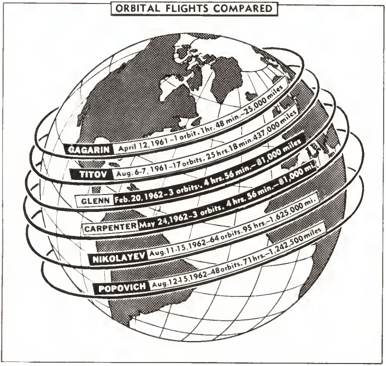
By mid-September 1962, the box score on known Russian and American satellite launches for terrestrial and solar orbits and deep space probes since the first Sputnik was this:

Soviet Union—26
United States—93

In addition, there were unknown numbers of military satellite launchings on both sides. But the known numbers explain neither the qualitative nor the quantitative differences between the two programs, nor do they admit an interpretation on who will reach the moon first. The top payload lifted by the United States in 1962 weighed somewhat more than two tons. The Soviet Union has claimed that its unmanned Sputnik VII test vehicle, launched for scientific studies, weighed in the neighborhood of seven tons. Nevertheless, four manned flights among the ninety-three orbital and deep space probe launchings by the United States have demonstrated a wide and sophisticated level of achievement. American scientific satellites have already permitted space studies of the earth's magnetic field and its trapped radia-

ide World

Wide World



The two Soviet astronauts who almost met in space: Andrian Nikolayev (left) and Pavel Popovich. Drawing above illustrates the relative durations of Soviet and American orbital flights up to the fall of 1962.

tion, solar emissions, ionospheric conditions and weather phenomena. There have been successful communications satellites like Echo, Score and Telstar, and also the military "eye in the sky" satellites like Samos and Midas. At this moment there is the apparently successful Mariner II, the 447-pound satellite launched on a 180,200,000-mile journey to Venus on August 27, 1962. It is expected to reach the vicinity of the cloud-shrouded planet on December 14. On its nineteenth day in space it was still transmitting radio signals loud and clear, four days longer than the best Russian Venus satellite. According to some American observers, the Soviet Union has not approached this over-all scientific record. Yet the space gap persists, just as it did in the days of the first Sputniks. President Kennedy, after congratulating the twin Vostok pilots, declared: "We are behind and will be behind for a period in the future." A month later, in a speech in Houston, Texas, he added: "The eyes of the world look into space—to the moon and to the planets beyond—and we have vowed that we shall not see it governed by a hostile flag of conquest." The challenge to the Russians was clear. It had been voiced earlier by the space agency director, James E. Webb, who said: "I happen to think we will make the manned lunar landing and return before they do." This American confidence is based not only on the ten-year, twenty-billion-dollar space program hinging on the flight to the moon, but also on United States industrial capacity, technical ability and knowledge of the problems involved in developing the really big boosters necessary for the moon trip. More specifically, it is based on the argument that both sides are working on the same sort of schedule. Leaving out the essential weight-lifting element, where the Russians are presently conceded a two-year lead, a comparison of United States and Soviet attainments has been a bit like comparing apples to peaches. Both fruits have their merits. And since the lunar landing depends on future space harvests more

than on present ones, many scientists have argued that estimates on ultimate victory were exercises in apple-peach semantics.

Leaving program differences aside, two experts associated respectively with the Air Force and the Department of Defense recently rated the Russians and Americans about even on rocket control and guidance ability. They gave the United States a lead in miniaturization of radio electronic equipment—a must for lunar spacecraft. And, of course, they conceded the Soviet weight-lifting lead. Ironically, it was the American lag in developing big rockets that led to the push for miniaturized, low-weight parts, just as it was the Russian lag in developing strategic air power that led them to build big boosters.

Critics of United States space developments have cited two major defects in the current program vis-à-vis the Russians: the first being its "stop and go" nature and the second its continuing devotion to "overdesign" and "glamour parts" rather than simplicity. "The Soviet program is definite and the Soviets have adhered to it," said Dr. Krieger in a recent interview. "Our program, however, has been subject to change." On the question of "overdesign"—that is, of components engineered to do more than they are supposed to—one of this country's most eloquent critics of complexity said not long ago that the evidence still favored the Russians on design simplicity. The critic, George Steele, a computer designer, observed: "Look at their pictures of launch pads. They are practically bare compared to ours, and apparently their astronauts don't need elevators to get into their space ships—they just climb ladders. The point is they are pretty straightforward in their design; no clutter. The Germans would have done it that way, too, but not this country." Another critic of American space engineering said: "We may get more per pound from our satellites than the Russians, but we have to. Ours probably cost more per pound, I'll bet."

Regardless of the mystery still surrounding the Nikolayev-Popovich expedition and previous Soviet space exploits, the propaganda triumphs deriving from them have been unmistakable. On the whole, the world has accepted the diet of space news prepared and served almost solely by Moscow without public confirmation from Western authorities. Except for a few sightings and private radio trackings outside the Soviet Bloc, virtually everyone was dependent on the Soviet agencies for news and most have taken it without complaining.

This has led some observers to argue that the United States should have used Soviet space announcements to pump more information out of the Russians, rather than simply accept their version of them. "Our position," said one student of Marxist propaganda techniques, "should always be to force the Russians to give more data." Dr. George Serban, a Rumanian refugee trained in communist psychological tactics in his homeland, has contended that the easiest way to do this would be for the United States to refuse official acceptance and approval of Soviet space reports until they could be confirmed by non-communist authorities. "The point about the communists is that they have needed acceptance and confirmation of their space exploits from the West," he continued, "but without paying the price of divulging much information for military reasons. But we overreact, saying we are not worried and thereby indicate that we are, and then we approve the flights in ways useful to the communists for winning the allegiance of neutral peoples."

Dr. Serban said that the statement issued by the Communist Party of the Soviet Union following the Nikolayev-Popovich flights was adequate testimony to his thesis. The statement said: "The new outstanding success in space exploration proves convincingly that communism is scoring one victory after another in the world competition with capi-

talism." The message was addressed to "All progressive mankind."

The leap to the moon is a most critical venture that will have a powerful influence on the prestige of the super powers—the only powers that can now engage in the race. How will the Russians make their leap: direct flight, lunar rendezvous or assembly of a vehicle in earth orbit? The last-named appears to be the mode chosen by the Soviet Union for its manned Lunik. Certainly, past Russian experiments with space platforms, as with the early Venus shots, would indicate that such a technique was favored, and there has been much talk in Soviet publications about this method, as opposed to the American plan for rendezvous in lunar orbit. There are also indications that both countries are working on development of unconventional booster and sustainer systems, including air-breathing engines and engines powered by nuclear energy, but the subjects are either classified or of low priority, and there is little public information on the progress of such work. One might presume, nevertheless, that Americans, as much as Russians, are interested in developing less costly and more efficient means of propelling space ships than the present liquid and solid fuel rockets.

Whatever the case, the conviction remains that the long and heavy haul to the moon and beyond will be at least as arduous for the Soviet Union as for the United States.

RICHARD WITKIN

Pros and Cons

How vital is space exploration? Does it matter whether the first footprint implanted on the first way station, the moon, is Russian or American? Is racing Russia to the moon worth an investment estimated (many think conservatively) at $20,000,000,000 over the next five to eight years?

The answers are political, military, economic and philosophical. Among the men who have been the driving force behind the nation's decision to make a race of it, the relative importance of these reasons vary widely. But all in all, they appear to have convinced an overwhelming proportion of the public, which has to pay the staggering bill, that the race should be run.

However, a number of respected officials and scientists think the decision was a cosmic mistake. They suggest that the United States would be wiser to slacken the lunar effort lest other vital projects—scientific, educational and perhaps military—be robbed of needed funds and technical manpower.

One of the bluntest of the slow-down school is former President Eisenhower. He said in a magazine article that

appeared in August 1962, shortly before Russia orbited its twin Vostoks:

"Why the great hurry to get to the moon and the planets? We have already demonstrated that in everything except the power of our rocket boosters, we are leading the world in scientific space exploration. From here on, I think we should proceed in an orderly way, building one accomplishment on another, rather than engaging in a mad effort to win a stunt race."

Eisenhower reiterated his stand after the Vostok flights.

Others go so far as to say that man has no business ever going to the moon, but this does not appear to be the real issue. Even among experts most critical of this nation's determination to race the Russians to the moon, the consensus is that, someday, man is going there. They merely question the need to compete and to pay the price that it entails.

A commonly heard variation of the "it costs too much" argument is sometimes stated this way: as long as millions the world over live like animals, as long as disease is rampant, as long as school plants and teachers' salaries are so inadequate, the United States should attack these ills rather than pour its wealth into a dubiously useful assault on the moon.

But it is not an either-or problem: either get to the moon or clear the slums. How much effective pressure was there for a multibillion-dollar attack on slums, or disease, or educational shortcomings before the competition in space began just a few years ago? If Project Apollo were scrapped tomorrow, would Congress vote even a fraction of the sums for these "alternative" projects? It is unlikely.

Up to now, even the arguments of the moderate objectors —those who want to go to the moon but at a pace that will not produce what they consider a distorted budget—have had little noticeable effect on Congress. Authorization of an increase in appropriations for the civilian space agency from \$1,700,000,000 to \$3,700,000,000 for the fiscal year ending

June 1963 was unanimously approved in both Houses. And this was before the orbital near-rendezvous of the two Vostoks, when no Soviet cosmonauts had been launched for months.

This is not to say that there has not been some Congressional uneasiness about the space budget. It has been reflected, perhaps most clearly and insistently, by Senator William Proxmire, Democrat of Wisconsin. In addressing the House Committee on Science and Astronautics at his own request, he said: "I do not object to our effort to land men on the moon. . . . The significant question is . . . at what rate such a program is carried on and what specific goals are set for it." Senator Proxmire urged the committee to request the space agency to make alternate proposals to show how a slower expansion of funds would affect the timetable for reaching the moon and other agency programs.

Dr. Warren Weaver, former president of the American Association for the Advancement of Science, has said: "I believe that most scientists consider the proposed expenditure quite unjustified on the grounds of scientific considerations, and also consider the frantic pace of the program to be wasteful." He itemized some of the things that could be done educationally with funds now expected to be allocated to the lunar project: a 10 per cent salary raise for ten years to every teacher in the country; $10,000,000 each to two hundred small colleges; seven-year fellowships of $4,000 a year for 50,000 new scientists and engineers (Russia is training such people much more rapidly than the United States); ten new medical schools; universities built and endowed for the more than fifty nations added to the United Nations since its establishment.

Worthy as these projects are, there are no signs now that they are going to be pursued at the expense of the space program, for reasons enumerated below.

The prime stimulus for the nation's accelerating thrust into

space has been, like so many things these days, competition with Russia. The competition covers a vast range of space activities, but its focus—by the deliberate choice of the United States—is on the race to the moon.

The reasoning of the Presidential advisers whose counsel was decisive in launching the lunar project appears to have run like this: The technical advantage that had enabled the Russians to score their firsts in space was that their large rocket boosters were much more powerful than anything developed so far in this country. The way to close the gap was to try to best the Russians in a particular competition where their present superiority in rocket power could not be decisive—in a competition that would require development of much more powerful boosters. The manned lunar landing seemed to be the first undertaking that would meet this criterion and be sufficiently impressive to the world at large.

President Kennedy's Congressional speech in which he formally proposed Project Apollo called specific attention to this aspect of a lunar landing:

"If we are going to win the battle that is now going on around the world between freedom and tyranny, the dramatic achievements in space which occurred in recent weeks should have made clear to all of us, as did the Sputnik in 1957, the impact of this adventure on the minds of men everywhere who are attempting to make a determination of which road they should take."

The achievements referred to were the Gagarin flight into earth orbit and the first space flight in this country, the 300-mile suborbital journey of Commander Shepard.

While noting that achievements in space might "hold the key to our future on earth," the President made no overt reference to the possible military implications of manned flight into space.

Since then, the Administration's public attitude on the

subject of manned military operations in space has wavered. In the spring of 1962 it disclosed plans for a broad new study of military requirements in space. It also revealed that it intended to develop the technology required for possible manned orbital systems able to inspect and neutralize other satellites and to land at preset locations on earth. Administration spokesmen repudiated suggestions, based largely on these disclosures, that there had been a significant increase in emphasis on military space efforts, but the following appears to be the Administration position: The military implications of manned space flight are to continue to be played down, at least publicly. The civilian space agency, the National Aeronautics and Space Administration, is to continue to have responsibility for most manned space-flight activities. If NASA research indicates there is a specific military mission that might be performed by a manned spacecraft, then the Air Force could be called upon to develop such a vehicle for its operational inventory.

The struggle of the Air Force strategists for a larger role in space is not essentially with NASA but with some key civilian officials in the Defense Department and also, it is reported, in the White House. This Administration policy has some vigorous opponents, including not only Air Force generals but also some respected civilians, in and out of government. These critics say Apollo and other NASA efforts are not enough; that technical "fallout" from Apollo cannot be relied on for filling potential military requirements; that the military should be working now on comparable projects peculiar to their needs.

It is extremely doubtful that, for the time being at least, the Air Force will get much of what it wants. As matters stand, it is pursuing a policy of co-operating to the hilt with NASA programs. In this way, it hopes to develop its technical talents to the fullest and insure its readiness to carry out

rapidly any new assignments eventually given it. Actually, the Air Force has been deeply involved all along in Apollo and other projects. So have the other services, to a lesser extent. To insure smoother co-operation between the military and NASA, an Air Force unit was created early in 1962 with experienced, high-ranking personnel assigned to deal directly with corresponding members of the Apollo staff.

There is irony in the continuing intra-Administration argument over the military implications of manned space flight. While the Administration publicly plays down these implications, there are influential members of Congress who state privately that, were it not for the military potential of space flight, the Administration would have small chance of winning approval of the huge NASA budgets.

But there are further arguments for Apollo besides the urgency of the race and its possible military advantages. Another rationale for going into space is an economic one. It has been suggested that the lunar project might pay for itself by spurring development of many devices—advanced transistors, protective clothing, improved lubricants—with wide application on earth.

The scientific community, while split on the urgency of putting humans aboard spacecraft, recognizes that space research is a means of unraveling many of the most provocative mysteries of the universe.

Some political scientists see a possibility that the awesome challenge of space could open the way to international cooperation that would dispel the specter of war. Still others suggest that, while war may not be banished, space may provide the arena for war and limit war's destruction on earth.

Finally, there are thc hard-to-define reasons for going to the moon that have to do with the gropings of the human spirit. President Kennedy, while pointing out in his Apollo speech that the nation must compete with the forces of

tyranny for the minds of men, also declared:

"But this is not merely a race. Space is open to us now. . . . And our eagerness to share its meaning is not governed by the efforts of others. We go into space because whatever mankind must undertake, free men must fully share."

Appendix

Space Glossary

ACCELERATION A rate of change of velocity. Any body experiences acceleration when its motion becomes faster or slower or changes direction.

APOGEE The point in an orbit where the satellite is farthest from the body it is orbiting.

APOLLO A Greek god for whom the American project for landing a man on the moon is named. He appears in Greek mythology as the god of poetry, music and prophecy, the patron of physicians and shepherds, and the founder of cities. In Homer he is also a warrior and sender of plagues. He became a god of light and heaven after slaying the earth-oracle, Python, symbol of the hostile powers of darkness, with his arrows, that is, sunbeams.

ASTEROIDS The thousands of minor "planets" that circle the sun, most of them between the orbits of Mars and Jupiter. Ceres, the largest, is more than 400 miles in diameter. Many are only a few miles across.

COSMIC RAYS Atomic nuclei, moving almost at the speed of light, that rain continually on the earth's upper atmosphere. Most are protons, the nuclei of hydrogen atoms, but heavier atoms, at least up to iron, are included. They constitute a form of radiation in space that may affect those exposed to it for prolonged periods.

CRATERS On the moon only a small percentage of the craters

resemble those on earth. Some are more than 100 miles wide. Some are clearly the result of impacts by meteorites or asteroids. Others may be a by-product of internal heat, like burst bubbles on the surface of boiling cereal, or of volcanic origin. About 30,000 craters, one or more miles in diameter, are visible.

DOCKING The joining of two space vehicles that have rendezvoused in space.

DOPPLER A shift in the apparent wavelength of sound, light or radio emissions, due to motion of the source toward or away from the receiver. The best known example is the change in pitch of a horn as a car or train passes an observer. Doppler is used in tracking moon vehicles.

DYNA-SOAR Orbiting space glider to be launched by the Titan III rocket. Known also as the X-20.

ELECTROMAGNETIC RADIATION The form of radiation of which light is the chief example. Its longest wavelengths are known as radio waves. Shorter radio waves are used for radar. Still shorter waves constitute infrared, visible and ultraviolet light, x-rays and —shortest of all—gamma rays. All travel at the speed of light (roughly 186,000 miles a second).

ELECTRON Lightest of the fundamental particles of matter. It carries a negative electric charge. The atom consists of a nucleus containing one or more protons, plus, possibly, some neutrons, with enough electrons outside the nucleus to balance the positive charge of the protons.

FLARE A solar eruption that seems to mark a release of accumulated magnetic energy. Clouds of particles fly out, often reaching earth a day or two later, producing disturbances of the earth's magnetism. A few flares shoot out high energy protons that spiral toward the earth at great speed, some arriving in less than an hour. These are a major hazard to space flight.

GEMINI The United States project for orbiting astronauts in two-man capsules. They will practice rendezvous and docking with other space vehicles. The name, taken from the Latin word for "twins," is also applied to a constellation of the Zodiac.

G-FORCE The force exerted on an object by gravity or by acceleration. One G, approximately, is the pull exerted on a body by the earth's gravity at sea level.

INERTIAL GUIDANCE A system for guiding space vehicles by acceleration-sensing devices that measure each change in velocity

or direction. The system then compares this data with that expected if the vehicle were on course and makes appropriate corrections in flight path.

IONIZATION The imparting of an electric charge to atoms and molecules by adding or subtracting electrons to and from their normal complement. Subtraction gives them a positive charge; addition gives them a negative charge. It can be caused in gases by heat, electric discharges or radiation. An ionized gas is a good conductor of electricity and will absorb some radio signals.

LANDER The model of the unmanned Surveyor capable of a soft landing on the moon.

LIBRATION The slight changes in the face of the moon visible from the earth. It occurs primarily because the moon's rate of spin on its axis is uniform, but the speed of flight in its elliptical path around the earth is not. Hence, although the moon keeps essentially the same face toward the earth, this face appears to twist slightly from side to side. Likewise, because the moon's axis is slightly tilted, we see more of its polar regions than we would otherwise. The total effect is to enable us to see some 59 per cent of the moon at one time or another, instead of only 50 per cent.

LYMAN ALPHA A wave length of ultraviolet light emitted by excited hydrogen atoms.

MERCURY The United States project for orbiting single astronauts. It is named for the Roman god of merchandizing, counterpart of Hermes, messenger of the gods in Greek mythology.

METEOR Popularly a "shooting star," a grain-sized object entering the earth's atmosphere with sufficient velocity to glow and be visible at night.

METEORITE Popularly, an object from space sufficiently large to survive the heat generated by its passage through the atmosphere. It may range in size from that of a rock to that of an asteroid. Some are made of iron and nickel, some of stone. There is no clear-cut distinction between a meteor and a meteorite, since survival of passage through the atmosphere depends, in part, on the speed and angle of arrival. Some astronomers define a meteor as a bit of debris left by a comet and a meteorite as a chunk of the material from which planets are made. Both will presumably be encountered in space; both probably produce "shooting stars."

NOVA The largest rocket presently envisaged by the United States. Still in the planning. In astronomy a nova is an explosive

increase in the brightness of a star.

ORBIT The path of one body around a far larger one. Johannes Kepler, in the seventeenth century, showed that the paths of such satellites are ellipses and that a line joining the satellite with its parent body always sweeps out an equal area in equal periods of time. Hence, an object moves slower at apogee than at perigee, which accounts for the chief component of libration. Sir Isaac Newton related the mass of the parent body (its gravity) to the speed and dimensions of the orbit.

ORBITER The model of the unmanned Surveyor designed to orbit the moon and send to earth photographs of the entire lunar surface. One of the earliest American satellite projects, never carried out, was also called "Orbiter."

PARAGLIDER An inflatable glider wing to be used in the landing on earth of Gemini capsules. Known also as a Rogallo wing or flexwing.

PARAMETER A variable factor that must be considered in any given problem.

PERIGEE The point in an orbit where the satellite is nearest the body it is orbiting.

PLASMA Highly ionized gas, such as that ejected by the sun or that within a fluorescent light tube.

PROTON The positively-charged particle of the atomic nucleus. The nucleus of the simplest atom, that of hydrogen, consists of a single proton.

RANGER An unmanned vehicle designed to land on the moon. Most Rangers will transmit television pictures of the lunar surface until a moment before crashing.

RAYS Streaks on the moon that radiate in all directions from certain large craters. They are apparently a by-product of explosions but cast no shadows visible from the earth.

RETRO ROCKET Rocket designed to slow a space vehicle. Such a rocket can terminate an orbital flight or enable the gravity of a body, like the moon, to capture a vehicle whose fly-by would otherwise be too rapid.

SATURN, ADVANCED The largest rocket now being developed in the United States. It will be the workhorse of Project Apollo. The configuration to be used for carrying astronauts to the moon is the Saturn C-5.

SATURN, C-1 The largest rocket fired from the United States to date. Although considerably smaller than the Advanced Saturn, it will be used to test equipment destined for the Apollo project.

SEAS Broad, dark, seemingly smooth areas of the moon originally thought to have been water. Actually, they are not entirely featureless.

SURVEYOR An unmanned vehicle carrying retro rockets powerful enough to enable it to land instruments gently on the moon or to inject itself into an orbit around the moon.

TEKTITES Small, glassy, streamlined objects found strewn over portions of the earth that some scientists believe are partly of lunar origin. Others think they were produced by the entry of meteorites into the atmosphere or as by-products of meteorite impact.

TELEMETER Automatic transmission of instrument readings to a distant receiving station. In space research it is done by modulating radio signals.

VAN ALLEN BELT A doughnut-shaped region centered around the earth's magnetic equator within which high energy particles are trapped in spiraling paths by the earth's magnetism. By some definitions there are two belts: an inner one, dominated by very high energy protons, about 1,000 miles above the equator, and an outer one, composed of both electrons and protons, that varies in step with solar activity and may be centered anywhere from 9,000 to 12,000 miles above the equator.

VOSTOK The name of the manned spacecraft that have carried the early Soviet astronauts into earth orbit. It means "East" in Russian.

WEIGHTLESSNESS The condition that occurs in free flight above the atmosphere when gravity is neutralized. The gravitational force is in equilibrium with the inertia imparted to the vehicle and its passengers as it is launched.

Moon Facts

Distances from the earth (center-to-center):	
Maximum (apogee)	252,710 miles
Minimum (perigee)	221,463 miles
Mean distance	238,857 miles
Inclination of orbit to the earth's equatorial plane	Varies from 18° to 29.5°
Inclination of orbit to the ecliptic (plane of the earth's orbit around the sun)	5°
Inclination of the moon's equator to the ecliptic	1.5°
Mean orbital velocity	0.6 miles per second
Sidereal period (mean duration of one orbit around the earth)	27 days, 7 hours, 43.2 minutes

Period of rotation on its own axis	Same
Synodical period (lunar month, or time from one new moon to the next. Differs from sidereal period because it depends on the relative position of the sun, which changes due to the motion of the earth-moon system around the sun)	29 days, 12 hours, 44.05 minutes
Diameter	2,160 miles
Mass (compared to that of the earth)	0.0123
Density (compared to that of the earth)	0.606
Surface gravity (compared to that of the earth)	0.16
Surface temperatures:	
Noon	261° (F)
Midnight	−243° (F)
Area visible:	
Always visible	41%
Sometimes visible, due to libration	18%
Never visible from earth	41%
Escape velocity (that of the earth is 7 miles per second)	1.4 miles per second
Highest peak (in Leibnitz Mountains, near south pole)	19,500 feet
Barycenter (center of gravity of the earth-moon system)	2,880 miles from the center of the earth

Tidal effects:	
Maximum ("spring" tides)	At full moon and new moon, when the gravitational attractions of the sun and the moon are parallel
Minimum ("neap" tides)	At first and last quarters, when the gravitational attractions of the sun and the moon are at right angles to one another
Ratio of the moon's tidal effect to that of the sun	11 to 5
Bulge of the moon toward the earth	Roughly 1 mile

Nomenclature:

The "seas" or dark areas of the moon bear Latin names, such as Mare Crisium (Sea of Crises), Oceanus Procellarum (Ocean of Storms) and Mare Imbrium (Sea of Showers). The craters are usually named for astronomers, such as Copernicus, Eratosthenes and Tycho. Some, however, honor explorers, monarchs and other prominent people—Alphonsus is named for a king of Spain. The mountains are largely named for earthly mountain ranges: the Alps, Apennines, Ural and Altai Mountains. From the crude pictures which the Russians obtained of the otherwise hidden area, they have, for example, named one feature Mare Moscoviae (Moscow Sea) and another the Soviet Mountains.

The chapters in this book are drawn from articles that appeared in the *New York Times*, most of them in the summer of 1962. The names heading each chapter are those of the principal authors, although some chapters contain material by other members of the *Times* staff. The editing of the original Apollo articles was by Dean Gladfelder, Irving Horowitz and Myron Marks under the direction of Harrison Salisbury. The maps and drawings, unless otherwise noted, were prepared by Andrew Sabattini and his colleagues in the *Times* Map Department. The material was edited for book publication by Walter Sullivan under the supervision of Jack Stewart.

TABLE OF CONTENTS

Foreword by D. Brainerd Holmes

Prologue: To the Moon — A Century Ago

1 We Are Going
2 Who Is Doing the Job?
3 How to Get There
4 Project Gemini—Learning to Live in Space
5 Spaceport U.S.A.
6 Journey by Phonebooth
7 Keeping in Touch
8 Perils of the Abyss
9 Moon Pioneers—Selection and Training
10 What Will the Moon Be Like?
11 Earth's Daughter, Sister or Uncle?
12 Exploration by Automaton
13 Tasks for the First Explorers
14 Space Infection
15 Social Impact
16 Soviet Enigma
17 Pros and Cons

Appendix

Space Glossary
Moon Facts